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THE KEARNEY AGITATION IN CALIFORNIA.

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ALTHOUGH something has been done toward the scientific treatment of history and of the larger facts of sociology, the conception of the reign of law amid human actions lags far behind the recognition of law in the material universe, and the disposition to ascribe social phenomena to special causes is yet almost as common as it is in the infancy of knowledge so to explain physical phenomena.

We no longer attribute an eclipse to a malevolent dragon; when a blight falls on our vines, or a murrain on our cattle, we set to work with microscope and chemical tests, instead of imputing it to the anger of a supernatural power; we have begun to trace the winds and foretell the weather, instead of seeing in their changes the designs of Providence or the work of witch or warlock. Yet as to social phenomena, infantile explanations similar to those we have thus discarded still largely suffice us. One has but to read our newspapers, to attend political meetings, or to listen to common talk, to see that very many people, who have in large measure risen to scientific conceptions of the linked sequence of the material universe, have not yet, in their views of social facts and movements, got past the idea of the little child who, if shown a picture of battle or siege, will insist on being told which are the good and which the bad men.

As the conductors of this magazine evidently realize the importance of popularizing in their applications to social questions the scientific spirit and scientific method, which in other departments have achieved such wonders, I propose in this paper to say something of a series of events in California that has attracted much attention. In an article

such as this, I can, however, do little more than correct some misapprehensions and put the main facts in such relations that their bearing may be seen. Much that would conduce to complete intelligibility must, from the limit of space, be omitted.

What seems to be the general idea of these events is well suggested by one of Nast's cartoons—a hideous figure, girt with revolver and sword, broadly badged as "communist," brandishing in one hand the torch of anarchy, and in the other exhibiting a scroll on which is inscribed: "Mob Law. The New Constitution of California. Kearneyism. Other people's homes, savings, land, property, lives, capital, and honest labor, all common stock in the universal coöperative brotherhood." In the distance a group of workmen stand idle and cowering, while underneath is the device, "Constant Vigilance (Committee) is the price of liberty in San Francisco."

While such ideas are but exaggerated reflections of the utterances of San Francisco papers, they are wide of the truth. There has not been in San Francisco any outbreak of "foreign communism," nor yet has there been in the workingman's movement, or in its results, anything socialistic or agrarian. This movement has in reality been inspired by ordinary political aims, and what has been going on in California derives its real interest from its relation to general facts and its illustration of general tendencies.

While there has been much in these events to recall to the cool observer the saying of Carlyle, "There are twenty-eight millions of people in Great Britain, mostly fools," it is yet a mistake to regard California as a community widely differing from more Eastern States. I am, in fact, inclined rather to look upon California as a typical American State, and San Francisco as a typical American city. It would be difficult to name any State that in resources, climate, and industries comes nearer to representing the whole Union, while, as all the other States have contributed to her population in something like relative proportions, general American characteristics remain, as local peculiarities are in the attrition worn off. There is, of course, a greater mobility of society than in older communities, and this may give rise to a certain excitability and fickleness. But, everywhere, the mobility of population increases with the relative growth of cities and the increase of facilities of movement. And, in fact, the newness and plasticity of society in such a State as California permits general tendencies to show themselves more quickly than in older sections, just as in the younger and more flexible parts of the tree the direction of the wind is most easily seen.

Though yet comparatively a small city, San Francisco is in character more metropolitan than any other American city except New York, and is, to the territory and population of which she is the commercial, industrial, financial, and political center, even more of a center than is New York. San Francisco has no rival. For long distances

her bay is spoken of as "the bay," and she is not merely the greatest city, but "the city."

And, though the European element is largely represented in San Francisco, it is, I am inclined to think, more thoroughly Americanized than in the Eastern cities. The reason I take to be, not merely that it is drawn from the more active and intelligent of the immigration that sets upon the Atlantic shore, and has generally only reached California after a longer or shorter sojourn in more Eastern States, but also that the American population having been drawn from all sections of the country, and from the early days the whole immigration having been rather of individuals than of colonies or families, the admixture has been more thorough, and, except as to the Chinese, that polarization which divides a mixed population into distinct communities has not so readily taken place.

Contrary, too, to the reputation which she seems to have got, San Francisco is really an orderly city. Although the police force has been doubled within the past two years, it still bears a smaller proportion to population than in other large American cities. Chinamen go about the streets with far more security than I imagine they will go about any Eastern city when they become proportionately as numerous; and, after all said of hoodlumism, there is little obtrusive rowdyism and few street fights—a fact which may in part result from the once universal practice of carrying arms.

Nor has communism or socialism (understanding by these terms the desire for fundamental social changes) made, up to this time, much progress in California, for the presence of the Chinese has largely engrossed the attention of the laboring classes, offering what has seemed to them a sufficient explanation of the fall of wages and difficulty of finding employment. Only the more thoughtful have heeded the fact that in other parts of the world where there are no Chinamen the condition of the laboring classes is even worse than in California. With the masses the obvious evils of Chinese competition have excluded all thought of anything else. And in this anti-Chinese feeling there is, of course, nothing that can properly be deemed socialistic or communistic. On the contrary, socialists and communists are more tolerant of the Chinese than any other class of those who feel or are threatened by their competition. For not only is there, at the bottom of what is called socialism and communism, the great idea of the equality and brotherhood of men, but they who look to changes in the fundamental institutions of society as the only means for improving the condition of the masses necessarily regard Chinese immigration as a minor evil, if in a proper social state it could be any evil at all. Nor is there in this anti-Chinese feeling anything essentially foreign. Those who talk about opposition to the Chinese being anti-American shut their eyes to a great many facts if they mean anything more than that it *ought* to be anti-American.

In short, I am unable to see, in the conditions from which this agitation sprang, anything really peculiar to California. I can not regard the anti-Chinese sentiment as really peculiar, because it must soon arise in the East should Chinese immigration continue; and because, in the connection in which we are considering it, its nature and effects do not materially differ from those which elsewhere are aroused by other causes. The main fact which underlies all this agitation is popular discontent; and, where there is popular discontent, if there is not one Jonah, another will be found. Thus, over and over again, popular discontent has fixed upon the Jews, and among ourselves there is a large class who make the "ignorant foreigner" the same sort of a scapegoat for all political demoralization and corruption.

There has been in California growing social and political discontent, but the main causes of this do not materially differ from those which elsewhere exist. Some of the factors of discontent may have attained greater development in California than in older sections, but I am inclined to think this is merely because in the newer States general tendencies are quicker seen. For instance, the concentration of the whole railroad system in the hands of one close corporation is remarkable in California, but there is clearly a general tendency to such concentration, which is year by year steadily uniting railroad management all over the country.

The "grand culture" of machine-worked fields, which calls for large gangs of men at certain seasons, setting them adrift when the crop is gathered, and which is so largely instrumental in filling San Francisco every winter with unemployed men, is certainly the form to which American agriculture generally tends, and is developing in the new Northwest even more rapidly than in California.

Nor yet am I sure that the characteristics of the press, to which San Franciscans largely attribute this agitation, are not characteristics to which the newspaper press generally tends. Certain it is that the development of the newspaper is in a direction which makes it less and less the exponent of ideas and advocate of principles, and more and more a machine for money-making.

There is, however, a peculiar local factor which I am persuaded has not been without importance. This is an intangible thing—a mere memory. But such intangible things are often most potent. Just as the memory of previous revolutions has disposed the discontented Parisian to think of barricades and the march to the Hôtel de Ville, so has the memory of the Vigilance Committee accustomed San Franciscans to think of extra-legal associations and methods as the last but sovereign resort. These ideas have been current among a different class from that which mans the Paris barricades. The Vigilance Committee of 1856, as most of the other California Vigilance Committees, was organized and led by the mercantile class, and in that class its memories have survived. The wild talk of the "sand-lot"

about hanging official thieves and renegade representatives, and the armed organizations of workingmen, which have seemed at the East like the importations of foreign communism, are in large measure but reflections and exaggerations of ideas current in San Francisco counting-rooms and bank parlors. And it must be remembered, in estimating the influence of this idea, that the Vigilance Committee of 1856 was not merely successful in its immediate purposes, but gave birth to a political organization that for many years thereafter managed the local government and disposed of all its large prizes.

Yet, acting with and running through this, has been, I think, a wider and more generally diffused feeling—the disposition toward sharp repressive measures which is aroused among the wealthy classes by symptoms of dissatisfaction and aggression among the poor. That this feeling has of late years been growing throughout the Union many indications show.

Be all this as it may, the impulse that began these California agitations came from the East. For the genesis of Kearneyism, or rather for the shock that set in motion forces that social and political discontent had been generating, we must look to Pittsburgh and to the great railroad strikes of 1877.

In California, where a similar strike was about beginning—for the railroad company had given notice of a like reduction of wages—these strikes excited an interest that became intense when the telegraph told of the burning and fighting in Pittsburgh. The railroad magnates, becoming alarmed, rescinded their notice, but in the mean time a meeting to express sympathy with the Eastern strikers had been called for the sand-lot in front of the new City Hall. This meeting was called in response to a request of Eastern labor papers, but happened to fall amid the excitement caused by the Pittsburgh riot. The over-zealous authorities, catching, perhaps, the alarm that had induced the railroad managers to rescind their reduction, arrested men who were carrying placards advertising the meeting. In the excitement, wild reports flew through the city that an incendiary meeting was to be held, and an attempt made to burn the Pacific Mail Docks and Chinese quarter. The meeting was held, for the authorities soon saw that there was no reason for preventing it. There was no talk of lawlessness or allusion to the Chinese on the part of the promoters of the meeting or their speakers, but the excitement showed itself by the raising, on the outskirts of the immense crowd, of the cry, "To Chinatown!" a movement promptly stopped by the police; and in remoter districts some Chinese wash-houses were raided by gangs of boys. The papers—sensational to the last degree—made the most of this the next morning, and, in the excitement that the Eastern news had created, a meeting, held in the rooms of the Chamber of Commerce, organized a Committee of Public Safety, with the President of the Vigilance Committee of 1856 at its head, the hint being probably given by a telegram that

the citizens of Pittsburgh had restored order by organizing a force armed with base-ball bats. In San Francisco the pick-handle was chosen instead, and for some days a large number of men so armed perambulated the streets. Space will not permit, nor is it necessary, to tell the story of this "battle of the kegs." Ridiculous in some of its aspects, it was serious in others. There was not the slightest necessity for this extra-legal organization and parade; but, while San Francisco was represented to the world as a city on the verge of riot and anarchy, a strong feeling of class irritation was engendered.

Among those who carried a pick-handle in this "pick-handle brigade," as it was christened, was an Irish drayman, who has since become famous. Dennis Kearney, a man of strict temperance in all except speech, had built up a good business in draying for mercantile houses, and accumulated, besides his horses and drays, a comfortable little property. Up to this time he had taken no part in politics, except to parade in torchlight processions as a "Hayes Invincible," but for some two years had been a constant attendant at a sort of free debating club, held on Sunday afternoons, and styled the Lyceum of Self-Culture, where he had gradually learned to speak in public, though the temperance which he practiced and preached as to liquor and tobacco did not extend to opinions or their expression. He was noticeable not merely for the bitter vulgarity of his attacks upon all forms of religion, especially that in which he had been reared, the Catholic, but for the venom with which he abused the working classes, and took on every occasion what passed for the capitalistic side. With all the vehemence with which he has since inveighed against "thieving capitalists" and "lecherous bondholders," he denounced the laziness and extravagance of workingmen, declared that wages were far too high, and defended Chinese immigration. Whether, with the suddenness not unnatural to such extremists, Kearney really changed his opinions while carrying his pick-handle, the change being hastened by some recent losses in stocks, or whether he merely realized what political possibilities lay in the general feeling of discontent and irritation, and how easily in times of excitement men may be organized, makes little difference. He laid down his pick-handle, to put his drays in charge of a brother, and go into politics.

His first appearance in his new vocation attracted no attention. The Safety Committee excitement passed immediately into the excitement of the impending legislative and municipal election. Besides the regular parties, a number of independent organizations or "side-shows" were in the field, many of them consisting only of a high-sounding name and an Executive Committee, who found their account in nominating candidates from the principal tickets and assessing them for election expenses, candidates who were spending money heavily, preferring to pay something to get on even the most insignificant ticket rather than risk the loss of the few votes that might determine

their election. Amid all these "parties," and "councils," and "clubs," the organization of a "Workingmen's Trade and Labor Union," with one J. G. Day as president and one D. Kearney as secretary, attracted no attention. This new organization, which, besides a president and secretary, boasted also a treasurer, stretched out a canvas bearing its name, and "resoluted" upon the necessity of "patriotism and integrity in the public offices from the lowest to the highest," calling upon the laboring classes to unite "to elect candidates in whom they can put their trust, and who are above suspicion." This being done, the new organization, by its president and secretary, proceeded in the usual way to ascertain which of the principal candidates were most above suspicion; but it printed no ticket, this particular movement to secure "patriotism and integrity in the public offices" winding up on the night before election in a row in which the treasurer and sergeant-at-arms vainly endeavored to make the president and secretary "come to a divide" on the amount collected, which they charged was between one and two thousand dollars.

But the master spirit of the ephemeral organization that thus unnoticed closed its life of weeks was no ordinary "price club man," who when one election is over retires from politics until the next approaches. The knot of men who had called the meeting of sympathy with the Eastern strikers had afterward organized a workingman's party and run a few candidates with a view to the future, but their intentions were brought to naught by the more energetic and audacious Kearney, who went to work without delay. On the Sunday after the election he again attended, for the last time, the Lyceum of Self-Culture, and, to the astonishment and amusement of the men whose ideas about the rights and wrongs of the working classes he had been berating, told them that they were a set of fools and blatherskites, and that he now proposed to start in with the demand of "bread or blood," and organize a party that would amount to something. The first move was a meeting to consider the Chinese question, at which a speech was made by a highly respected and prominent citizen; but when Kearney, who officiated as secretary, got the stand, he dealt out some more highly seasoned mental stimulant by reading a description of the burning of Moscow as a suggestion of what might be in store for San Francisco. Then appropriating the name of Workingman's party, Day and Kearney took to the sand-lot, enlisting some other speakers. Though violent, these harangues would have attracted little attention, and in fact the movement might have been choked in infancy (for several rival factions started up, and opposition platforms were erected within a few feet of each other), but for a powerful ally of just the kind needed.

The two San Francisco papers of largest circulation are the "Call" and "Chronicle," between whom intense rivalry has long existed. The "Call" has the greater circulation and more profitable business, drawn largely from the working classes. It is a good newspaper, but

its editorial management is timorous to a ridiculous degree. The "Chronicle," whose principal proprietor recently lost his life in a tragedy growing out of these occurrences, is best described as a "live paper" of the most vigorous and unscrupulous kind. As though a tacit partnership had been formed, Kearney began to call upon workingmen to stop the "Call" and take the "Chronicle," while the "Chronicle" on its part advertised the meetings in the highest style of the art, giving Kearney the greatest prominence and detailing its best reporters to manufacture and dress up his speeches. Thus advertised, the meetings began to draw.

California Street Hill is crowned by the palaces of the railroad nabobs—men who a few years ago were selling coal-oil or retailing dry goods, but who now count their wealth by the scores of millions. To complete the block which one of these had selected for his palace, an undertaker's homestead was necessary. The undertaker wanted more than the nabob was willing to give, and the latter cut short the negotiation by inclosing the undertaker's house on three sides with an immense board fence, probably the highest on the Pacific coast, if not in the world. This veritable coffin, which shuts out view and sun from the undertaker's little home, and which the common law, now abrogated in California by the code, would not have permitted, is one of the most striking features of the Hill.

When, with the assistance of the "Chronicle," the meetings had begun to draw crowds, largely composed of unemployed men, who after the harvest begin to collect in San Francisco, and of a class that of late years has become numerous, the professional beggars or strikers, a meeting was called for the top of California Street Hill, where the nabobs were regaled by the cheers of a surging crowd, when it was proposed by one of the speakers—a pamphleteer and newspaper writer well known in California for many years, but who neither before nor since took any other part in the agitation—to celebrate Thanksgiving by pulling down the big fence, if not removed by that time. This was too much: the railroad magnates were frightened—even the "Chronicle" demanded the arrest of the agitators; a sudden energy was infused into the authorities, and they, with the proposer of the fence-destruction, were arrested on charges of riot.

That these arrests were ill advised the sequel proves. And it is to be remarked that in all Kearney's wild declamation there has been no direct incitement to violence. He has talked about wading through blood, hanging official thieves, burning the Chinese quarter, and generally "raising Cain," but it has always been with an "if." He has never come any nearer to actually proposing any of these things than Daniel O'Connell did to proposing armed resistance to the English Government. Nor yet is it easy to point to anything which Kearney has said that is really more violent or incendiary than things said before with impunity. It was not Dennis Kearney, but a Republican

leader, a man of wealth, ability, and influence, who has held high position, and was this year a prominent member of the National Republican Convention, who first proposed that the Pacific Mail steamers should be burned at their docks if they did not cease to bring Chinese; it was a bitter opponent of Kearneyism who, amid thunders of applause, in the largest hall of the city, first suggested that the Chinese quarter should be purified with fire and planted with grass; while as to bitter denunciations of parties, classes, and individuals, and prognostications of violence and calamity if this, that, or the other was or was not done, there is probably nothing that Kearney or his fellows have said that could not be matched from previous political speeches or newspaper articles. That dangers may sometimes arise from an abuse of the liberty of speech may be true, but it is so exceedingly delicate a thing to attempt to draw any line short of the direct incitement to specific illegal action, that the only course consistent with the genius of our institutions is to leave such abuses to their own natural remedy. It is only where restrictions are imposed that mere words become dangerous to social order, just as it is only when gunpowder is confined that it becomes explosive. Had the energy of the authorities been reserved for any lawless act, and these agitators been left to agitate to their full content, except so far as they might interfere with the free use of the thoroughfares, any momentary interest or excitement would have soon died out, and the contempt which follows swelling words without action would soon have left them powerless. But the timidity which attaches to great wealth gained by questionable means, and at once arrogant in its power and keenly sensitive of the jealousy with which it is regarded, renders its possessors, surrounded as they must be by sycophantic advisers, insensible to reason in moments of excitement. "The thief doth fear each bush an officer." And the man who from the windows of a two-million-dollar mansion looks down upon his fellow citizens begging for the chance to work for a dollar a day can not fail to have at times some idea of the essential injustice of this state of things break through his complacency, while murmurings of discontent assume vague shapes of menace against which fear urges him to strike, though reason and prudence would hold back a blow which can only irritate. The dangers to social order that arise from the glaring inequalities of wealth come as much from this direction as from the discontent of the less fortunate classes. It was this feeling that, organizing the "pick-handle brigade," prepared the way and gave the hint for agitation; it was this feeling that, now striking blindly through the authorities, gave to that agitation dignity and power.

More efficient means to provoke a public sentiment in favor of the agitators could not have been taken. Not only were the speakers arrested on charges which would not bear legal scrutiny, but new warrants were sworn out as quickly as bail was offered. A pledge made

by the agitators in prison, to hold no more outdoor meetings and use no more incendiary language if the charges against them were dismissed, was refused, and special counsel were employed to prosecute. Outside the prison the same drunken spirit of arbitrary repression showed itself, not only by driving crowds from the streets, but by breaking up indoor meetings and installing captains of police as censors.

The reaction was swift and strong, but it was not at first heeded. The charges against the agitators were dismissed by the judge before whom they were brought, but fresh charges were made, which were dismissed by juries. An ordinance was rushed through the Board of Supervisors, under which it has never been dared to bring an action; a ridiculously oppressive law was hurried through the Legislature, which was similarly a dead letter, and which at the next session was repealed without a dissenting voice and hardly a dissenting vote.

These impotent attempts at repression produced their natural result. The new party was fairly started, brought into prominence and importance by the intemperance which had sought to crush it.

The feeling on the Chinese question has long been so strong in California as to give certain victory to any party that could fully utilize it. But the difficulty in the way of making political capital of this feeling has been to get resistance, since all parties were willing to take the strongest anti-Chinese ground. But the fear that the agitators had evidently inspired, the effort to put them down, served as such resistance; and, though all parties were anti-Chinese, the party they were endeavoring to start became at once *the* anti-Chinese party in the eyes of those who were bitterest and strongest in their feeling, while it at the same time became an expression, though rudely and vaguely, of all sorts of discontent. It was evident that it would be a political power for at least one election. The lower strata of ward politicians went rushing into it as a good chance for office; the "Chronicle," which, at the first symptom of reaction, had redoubled its services, placarded the State with resolutions of the new party asking workingmen to stop the "Call." That paper, losing heavily in subscribers, quietly began to outdo the "Chronicle" in its reports and its puffery. Other papers, recognized as organs of interests popularly regarded with dislike, did their utmost by denunciation to keep Kearney in the foreground. Republican politicians saw in the movement a division of the Democratic vote worth fostering; Democratic politicians saw in it an element of future success, on the right side of which the political wise man would keep; the municipal authorities, remembering coming elections, passed from persecution to obsequiousness; while the great railroad interest either came to a tacit understanding, or had its agents install themselves in the new organization,* using it to help their friends

* There have been no more meetings on Nob Hill, or denunciation of the railroad magnates or great bonanza firm. On the contrary, all the officials elected by the workingmen seem to have been either employees or friends of the railroad, or people who

and keep out their enemies, as they aim to use, and generally succeed in using, all parties, and men of high social standing did not hesitate, when it served their purpose, to furnish points and matter for sand-lot harangues, or to speak at meetings which Kearney and his gang had captured; for, until they met a very warm reception at a Democratic meeting, they arrogated to themselves the right to interrupt and "bull-doze" any meeting that did not suit them.

Kearney had quickly come to the head of the movement, changing his first place of secretary for that of president shortly after taking to the sand-lot, and having, by the time he and his companions emerged from jail in triumph, got so well to the head as to become in the popular eye its representative and embodiment. He showed great address in keeping the place. The organization which he managed to give the new party was admirably designed for this purpose. The weekly assemblage on the sand-lot, where anybody could shout and vote, was recognized as the great parliament and plebiscitum, and in the State conventions, in which the country as well as the city clubs were represented, the supremacy of the city clubs was provided for by the interdiction of proxies. As president of the party (something new in American politics, but an idea probably borrowed from the Committee of Public Safety), Kearney was anything but a mere figure-head. He has seemed to see, as clearly as any philosophical student of history has seen, the true spring and foundation of arbitrary power—the connection between Cæsar and the proletariate.

He appeared on all occasions in rough working-dress; he announced that he would take no office, but, as soon as he had led the people to a victory, he would go back to his dray, and must in the mean time be supported by collections, for which he passed around the hat at every meeting. These things, the style of his oratory, the prominence he had attained, his energy, tact, and temperance, gave him command of that floating element which will travel around to the most meetings and do the loudest shouting. And, commanding this, he commanded his party.

Presiding at the sand-lot, he claimed the right to say who should speak and to put all questions, and, traveling around from club to club, accompanied by a crowd of admiring followers, who voted just as the Parisian rabble did in the Revolutionary clubs and conventions, he took possession wherever he went. Availing himself of the feeling against politicians and political chicanery, he declared parliamentary law to be political trickery, and put motions as he pleased, or didn't put them at all, and for him to denounce any mutineer as a politician was to doom him to immediate "firing out." This was the fate, one after the other, of all the men who had begun with him the agitation, and of all those who from time to time began to gain any prominence which might

could not harm them, while a confidential attorney of large moneyed interests has been the reputed confidential adviser of Kearney.

endanger his supremacy. By a single *coup d'état* he swept out the whole Central Committee the moment they began to show a disposition to have some voice in the management of the party, alleging, as was naturally the fact, that they were candidates for office. No one was allowed to enter who had talent or influence enough to become a rival; no one was allowed to speak who would not constantly belaud "our noble leader"; and the men whom he selected as his lieutenants and allowed to come to the front were, without exception, not only men who accepted of these conditions, but men who for some reason or other stood in such relation to the controlling element of the party that he could at any time he chose turn on them and fire them out.* By this denunciation of politicians, by thus striking down every head that raised itself in his organization, he not only appealed to prejudice and jealousies, but to the personal interest and ambition of the club membership. The political hewers of wood and drawers of water, who made up the clubs, flattered themselves with the idea that *they* were the men of whom sheriffs, and supervisors, and school-directors, and Senators, and Assembly-men were to be made, and they brought to the new party and to the support of Kearney all the enthusiasm which such a hope called forth.

It may seem strange that a party thus constituted and led should poll such a heavy vote. But in our large cities, and progressively in the country as a whole, the active managing portion of a party bears a very small proportion to the vote which it polls. In New York or Philadelphia, as in San Francisco, but a handful of men make the tickets between which, on election-day, the majority of voters must choose. So in this case the heavy vote came from people who never joined the clubs or visited the sand-lot—from people who were so utterly disgusted with the workings and corruptions of old parties as to welcome "anything for a change."

And this feeling was greatly intensified by a train of occurrences which called attention to the prevailing corruption. Kearney's tirades against daylight robbers and official thieves had a basis of fact. To say nothing of bank-failures and stock-swindles, it came to light that brokers were engaged in selling positions on the police; that the questions upon which the teachers in the public schools are appointed and promoted were regular articles of merchandise; and that, running through successive administrations, the most enormous stealing had been going on in street improvements. Three important municipal officials committed suicide, one after another, and, behind all that came

* To illustrate what I mean, the man whom Kearney made vice-president, and who assumed his place during his absence, was an unnaturalized Englishman, who had been a sort of anti-Catholic missionary, and who could for this and other reasons get no lasting hold upon the Irish, of whom the active party was largely composed, and whom, when Kearney finally chose to, he flung aside without the slightest trouble. This was not an exception, but the rule.

to light, there was a mass of corruption never to be developed, for justice in San Francisco, as in some other places, seems stricken with palsy in presence of rich criminals and powerful rings.

The only remedy which the new party offered for this state of things was the usual remedy, "Elect honest men to office, we naming the honest men;" but in the beginning Kearney proposed the additional safeguard of hanging officials who broke their pledges. And, at the first election in which the new party engaged—to fill a vacancy in the legislative representation of the strong Republican county of Alameda, where the railroad interest is very powerful, and the population consist largely of San Francisco business men—the workingmen's candidate, a railroad employee named Bones, went around with a halter about his neck in token of his acceptance of this condition. He was elected, took his seat, and immediately began voting just as he had promised not to. There was enough discussion of how he should be hung to make him ask the protection of the Senate, but there was no hanging. This ended faith in that guarantee, but not in pledges, the municipal officials subsequently elected by the workingmen in San Francisco being pledged to draw only half salaries—a pledge which after election they one and all ignored as easily as before election they had taken it.

But, before the feelings which had been aroused by the events of which I speak could spend themselves in a general election of officers, there came, in June, 1878, the election for delegates to a Constitutional Convention. This whole subject of the new Constitution of California is extremely interesting and suggestive, but I can only allude to some main features. The large corporate interests took advantage of the situation, by starting a movement for a "Non-Partisan" ticket, on which, of course, they got a good representation. If they did not also engineer the Workingmen's nominations, they could hardly have done better, as these consisted generally of men utterly ignorant and inexperienced. The "Non-Partisans" carried the State at large, the Workingmen San Francisco and some other centers where they had organizations. The Convention itself was vaguely divided into three groups: first, the lawyers, who largely represented corporation interests; second, the "Grangers," who represented the ideas and prejudices of the farmers and landholders; third, the Workingmen, bent on making capital for the new party, and desirous of doing something for the laboring classes, without the slightest idea of how to do it. But there was nothing in the Convention like agrarianism or socialism, or radical reform of any kind. The lawyers looked out pretty well for their special interests; the Workingmen, satisfied with some clauses about the Chinese, etc. (not worth the paper on which they were written), readily fell in with the Grangers, imagining that, in piling taxation upon capital and all its shadows, they were helping the poor by taxing the rich. The resulting instrument is a sort of mixture of constitution, code,

stump-speech, and mandamus. But it is anything but agrarian or communistic, for it intrenches vested rights—especially in land—more thoroughly than before, and interposes barriers to future radicalism by a provision in regard to amendments which it will require almost a revolution to break through. It is anything but a workingman's Constitution: it levies a poll-tax without exemption, disfranchises a considerable part of the floating laboring vote, introduces a property qualification, prevents the opening of public works in emergencies, and in various ways, which workingmen, even in their present stage of enlightenment, may easily see, sacrifices the interests of the laboring classes, as well as the capitalist, to what the land-owners regard as their interests, while in other respects its changes, which are in the same direction as other late constitutions, are out of the line of true reform.

But anything like calm discussion of the work of the Convention became impossible. The moneyed classes of San Francisco, taking alarm at the taxation clauses, raised a fund of some hundreds of thousands of dollars to defeat the new Constitution, which was placed in the hands of the head lobbyists of the railroad company, and a regular bureau opened, while threats of the discharge of employees and withdrawal of patronage as penalty for voting for it were freely made. If, as believed by many, large special interests were engaged in the support of the new Constitution, they had the intelligence to work quietly. On the surface it seemed as if every tyrannous and corrupt influence was united for its defeat. In the torrent of passion which raged, it is difficult to say whether those who opposed or those who advocated the new Constitution said the most absurd things. On the one side it was denounced as a "communistic" instrument which would bring every calamity, on the other it was advocated as "the Magna Charta of the laboring classes." The real agrarians and communists, if these terms be applied to men who desire fundamental changes, opposed the new Constitution all they could. But the fact that enormous sums were being spent to defeat it, subjected every one who opposed it to the imputation of being the hireling of anti-popular interests. And so, with the solid vote of the farmers, aided largely by the vote of those who lose most by it, the new Constitution was carried.

In this contest the Workingmen had become, as in the Convention, a sort of tail to the Grangers' kite, and Kearney had to a great extent been forced into the background, while a number of old "war-horses" came to the front. The "Chronicle," which had made a vigorous fight for the new Constitution, saw in this combination an opportunity to make a new party of its own which should fill all the offices under the new instrument, and Kearney was given to understand that he might now retire on his laurels. This he very vigorously declined to do, and war between the late allies commenced, the "Chronicle" printing with little immediate effect long exposures of the man it had so much lauded, and Kearney denouncing the New Constitutionalists as "Hon-

orable Bilks," a name which derived its significance from the number of ex-Honorables in their ranks, and which stuck so tightly that they even began to speak of themselves as "the Bilks." As showing how much agrarianism there is in the new Constitution, the candidate of that party for Governor, an ardent supporter of the instrument, is the largest farmer in the State, the owner of something like a quarter of a million acres!

Both Republicans and Workingmen ran State tickets, while the Democratic party degenerated into a sort of "price club," ready to trade nominations with anybody who would make a combination. In this three-cornered contest the Republicans carried the State by a plurality, except where the other parties were united on the same candidate, and except as to San Francisco. Here the Workingmen's ticket was headed by the Rev. Dr. Kalloch, a leading Baptist clergyman well known at the East, and of great ability as a stump-speaker, who in the beginning of these events had the largest Chinese Sunday-school in the city, and preached the virtues of dealing with mobs by loading with grape and firing low, but who, when the movement assumed political force, shut up his Chinese Sunday-school and preached in such a different key that he completely captured the Workingmen, and was finally (though not by Kearney's wish) nominated by them for Mayor. The crack of De Young's pistol from behind the curtain of a *coupé* fired Dr. Kalloch into the mayoralty and gave the Workingmen several municipal officers and a number of members of the Legislature, besides such candidates as had united their nomination with that of other parties. But about none of the men thus carried into office in whole or in part by the Workingmen's vote is there anything socialistic or communistic. They are merely ordinary office-seekers who took advantage of the Workingmen's organization as giving a certain vote, and who, though generally they would have endorsed communism had it been popular, would have done so no quicker than they would have endorsed imperialism or Mormonism or spiritualism or vegetarianism.

After this election, and during Kearney's absence in the East last winter, began a new movement which, however, did not emanate from the Workingmen's party proper, and was led by new men—the meeting and marching of the unemployed, demanding of large employers the discharge of the Chinese. The alarm this excited, until the advance of the season and the consequent demand for laborers in the interior had lessened temporarily the number of unemployed, led to the reorganization of a Committee of Safety, which enrolled a good many names and spent some money in paying the militia to guard their arsenals,* but

* A job which the jovial sons of Mars rather liked, as it gave them three dollars per night for privates and five dollars for officers, and the necessity for which of course they did not belittle. In fact, in some of the night watches such expedients for continuing the excitement as getting on the outside and chucking bricks through the windows were discussed, if not put into practice.

made no parades. To this organization, however, I do not attribute the defeat of the Workingmen in the March election in San Francisco for a joint Senator and freeholders to frame a charter. It was in the natural course of things that the Workingmen should be beaten, even though the Democratic organization endorsed their candidate for Senator and nominated no freeholders. For a party without national affiliations or definite aims must die with its first success, and this is peculiarly a party that has been only kept alive by the mistakes of its opponents.

That Kearneyism had run its course was clearly evident in San Francisco after this election. The new Constitution has proved a bitter disappointment to those who expected so much from it; the officials elected by Workingmen have proved no particular improvement; disintegration was fast showing itself in the clubs, and Kearney was rapidly losing his popularity and influence with the class that had followed him. But a perceptible check was given to this decline when Kearney was sent to jail and fined a thousand dollars for an offense ordinarily punished by a trivial fine when punished at all. Thus made a victim, Kearney every day he staid in jail was gaining in popularity and strength as he had before, and when released by the Supreme Court was drawn in triumph through the streets on one of his own drays.

This brief sketch, though necessarily very imperfect, will accomplish all I intend if it makes the general facts and course of this agitation sufficiently intelligible to enable thoughtful men to see its true relations and real meaning. That a rude, uncultured drayman, with no previous influence over any class, should acquire such notoriety and wield such power, that a great city should so long have been kept in a state of excitement, are phenomena which more imperatively demand that careful and dispassionate attention which we call scientific than any conjuncture of the planets or appearance of spots on the sun. For, while we know that during unnumbered ages this great celestial machine has pursued its orderly movements, we also know that, while day has followed night and harvest succeeded seed-time, human society has been subject to the most terrible perturbations and cataclysms. And what has been going on in California betokens the social unrest and discontent from which destructive forces are generated.

That these events do not spring from exotic or abnormal causes seems to me clear. This agitation is not the result of the importation of foreign ideas, but the natural result of social and political conditions toward which the country as a whole steadily tends, and its development has been on lines strictly American. Kearney is not a type of the fanatical reformer, but of the politician, and possibly in a rough sort of way, not of the "coming Cæsar" of whom we hear so much, but of the real Cæsar whom we may one day evoke; the workingman's movement has been essentially nothing more than an ordinary

political movement growing from and taking advantage of popular discontent; while the new Constitution of California, destitute as it is of any shadow of reform which will lessen social inequalities or purify politics, exhibits the same tendencies as the newer constitutions of other States.

That Kearney or any considerable number of his followers ever seriously thought of an appeal to force, either to get rid of the Chinese or for any other purpose, I have not the slightest idea. The workingmen's military companies, of which a few were formed, would not have been at any time a flea-bite to the strong and well-appointed militia of the city, and were merely an amusement—a sort of set-off and imitation of the Committee of Public Safety. And it must be remembered that these vague suggestions of violence not only, as I have before said, secured resistance which turned latent force into political power, but the agitation did considerably check Chinese employment and immigration, while the passage of an anti-Chinese bill by Congress (though this bill was denounced at the time by Kearney), was claimed as one of its results.

And though capital has been frightened, at times seriously frightened, by this agitation, it must not be thought that this fright has been shared by all the property classes. On the contrary, the inner and influential circle of Kearney's backers and supporters have been men of more or less property, and large moneyed interests have sought to use the movement. Neither in platforms nor candidates has there been any leaning to the questioning of property rights. One Parisian communist was elected to the Convention, but he exercised no influence, and was expelled from the party for refusing to support the new Constitution. But, with this exception, the Workingmen's candidates have been no more radical than the average of American politicians. At the last election, for instance, their ticket was headed by a graduate of the University of California, who has been prominent in the party since it first assumed importance, and one of its candidates at every election. He belongs to a Jewish family who do a profitable manufacturing business, and not only disclaimed anything like socialism or agrarianism, but appealed to the corporation lawyers with whom he served in the Convention to certify to his conservatism. And next to him came a rich land-owner who has given a hundred thousand dollars for the establishment of a law-school, of which he is dean. What Kearney and his party have practically proposed has been merely the remedy which their preachers, teachers, and influential newspapers are constantly prescribing to the American people as the great cure-all—elect honest men to office, and have them cut down taxation; a remedy which belongs to the same category as the recipe for catching a little bird by sprinkling salt on its tail!

Now, I do not mean to say that there has been nothing in this movement to excite alarm; that the classes whose fright has led them

into foolish actions have been frightened entirely by their own shadows; or that, if by communism is meant a blind bitter irritation with things as they exist, there has not been communism in it. On the contrary, at the bottom of all this is deep social and political discontent. It is not radical, because it is not intelligent. It has been willing to follow those who promised really nothing; it has demanded only quack remedies because it is ignorant. But it is this that makes it dangerous. Ignorance, inflamed by passion, is the most terrible and destructive of monsters. The *Jacqueries*, the massacres, the reigns of terror, the revolutions which have overthrown one tyrant only to put a worse one in his place, have not been the work of those intelligent enough to see that social and political evils arise from wrong systems, but of those who, not quarreling with systems, charge the evils from which they suffer upon the wickedness of individuals or classes.

Had this movement involved anything which could properly be styled socialistic or communistic, it would have seemed to me hopeful, for socialism and communism involve some sort of theories which show at least a groping for real remedies. But what seems to me ominous in all these events is, that they show how easily our political struggles may pass into all the bitterness and dangers of excited class-feeling without calling forth any principle of improvement or reform. There is a comfortable belief widespread among us that, under a popular government, social and political evils tend to cure themselves by arousing the attention of the people. This would be true if, when the people became conscious of an evil, they stopped to think about its cause and its cure instead of following the first demagogue who, flattering their prejudices and appealing to their passions, promised them a cure. But this is not the lesson of history, nor yet does it seem to me the lesson of observation. What has been passing under my eyes has, with much greater vividness and force than I can convey in such a brief sketch, appeared to me to show the play of the same forces that have over and over again brought despotism out of freedom, anarchy out of order, and turned progress into retrogression. Popular government is not a new thing. All government in its beginning must have been popular government. And under all forms of government the people are the source of power. The force with which despots and tyrants, enslavers and destroyers, have worked has always been the force of the people themselves. *Vox populi vox Dei!* If that means anything more than that majorities are the source of power, it is as absurd a superstition as the faith in Mumbo Jumbo.

The danger to social order is not a direct one. The forces that would rally at any open assault upon it have with us overwhelming strength. The real danger comes through forms of legality and methods of government. Tweed and his little band would have been lodged in jail in a trice had they directly attempted their robberies; yet Tweed and his handful for years levied at their will upon the wealth of New

York and flaunted their spoils in all men's eyes. The man who now talks about wading through blood and hanging people to lamp-posts is but the vender of a nostrum who dresses as a wild Indian to attract attention; but when blind fear and unreasoning resentment sway the Government, and give to whoever can arouse them the prizes of place and power, the day when blood will flow and cities burn may not be so far off. There has never yet been any danger of mob violence in San Francisco; and yet, watching what has been going on there, it has seemed to me that I could see how jealousy and fear and hatred and revenge might mount through a series of actions and reactions to the point where reason is utterly trodden under foot; that I can understand better than before how faction piled the streets of Jerusalem with corpses, while Titus thundered at her gates; how the colors of circus-charioteers divided Constantinople into two hostile camps; how the reappearance of French liberty ushered in Red Terror and White Terror. It is true that we have the public school and the daily paper; that any child can tell you the distance of the sun, and how this system once rolled a mass of incandescent vapor. But, "scratch a Russian and you have a Tartar." Look at your civilized man when fired by that strange magnetic impulse which passion arouses in crowds, and you may read in his eyes the blind fury of the Malay running amuck. You will understand how handkerchiefs hemmed with the sewing-machine might be dipped in blood, and hearts carried on pikes through streets lit with gas!

Aristocracies, hierarchies, established orders, hereditary castes, and strong religious beliefs that have become conservative, they are like the trees and the fences that check the violence of the blast that over a dead level rushes in headlong fury—like the ballast in a ship that resists the sudden lurch. But these we have cast off or are casting off. Government with us grows in weight and importance; but this is not a conservative force when its increasing powers and emoluments are to be grasped by whoever can best organize corruption or rouse passion. We have great and increasing accumulations of wealth; capital is becoming organized in greater and greater masses, and the railroad company dwarfs the State. But these are not forces of stability. Perhaps these great combinations are forced into politics in self-defense. But, however they get there, their effect is but to demoralize and corrupt—to reward and to bring to political leadership the unscrupulous. And these great corporations themselves are but the prize and prey of adventurers, the fattening-places of unscrupulous rings.

Given universal suffrage; a vague, blind, bitter feeling of discontent on the one side and of insecurity on the other; unscrupulous politicians who may ride into power by exciting hopes and fears; class jealousies and class antipathies; great moneyed interests working through all parties with utter selfishness; a general disgust with political methods and feeling of practical political impotence, producing

indifference and recklessness on the part of the great mass of voters—and any accident may start a series of the most dangerous actions and reactions. Such a community is like a ship with an ill-stowed cargo. In light winds and smooth water all may seem secure; but in the strain of a heavy sea what should be the element of stability becomes an element of danger, and may throw her upon her beam-ends or tear her to pieces.

What has been going on in California is not out of the natural course of things. The forces that have produced these events have been developed, not imported. And as it seems to me that the same forces exist in other parts of the country, I can not see why, essentially, the same movements may not soon begin elsewhere. It is this that makes these California experiences worthy of attention. Every result becomes in turn a cause; every event is the progenitor of future events. And it is probable that this California agitation marks the beginning of a new phase in our politics. Whatever be his future career, Kearney has already made what will be regarded by thousands and thousands of men, many of them of much greater abilities, as a dazzlingly brilliant success. An unknown drayman, destitute of advantages, without following or influence, he has, simply by appealing to popular discontent and arousing the uneasy timidity which is its correlative, risen to the rank of a great leader, and drunk the sweets of power and fame. He knows what it is to be the hero and the master of surging multitudes; to draw forth their applause by a word, to hush them into silence with a wave of his hand; to be garlanded with flowers; to be drawn in triumph through crowded streets; to be attended wherever he went by a retinue of reporters and correspondents; to rise every morning to find the newspapers filled with him; to have men, who would not have noticed him had he stuck to his dray, slink by night to his house, or solicit his favors by go-betweens; to look upon high officials as the creatures of his making; to be known and talked about, not merely through the whole country, but over the world! Whatever becomes of Kearney—and it would be rash to predict that his career is yet over—this lesson will not be lost: The wave rises, curls, and subsides, and, where was its white crest, are but some spumes of foam. But the impulse is perpetuated, and another wave swells up.

When, under institutions that proclaim equality, masses of men, whose ambitions and tastes are aroused only to be crucified, find it a hard, bitter, degrading struggle even to live, is it to be expected that the sight of other men rolling in their millions will not excite discontent? And, when discontented men have votes, is it to be expected that the demagogue will not appeal to the discontent, for the sake of the votes? It is useless to blink the fact. Nothing is clearer, to whoever will look, than that the political equality from which we can not recede, and the social inequality to which we are tending, can not

peacefully coexist. Nothing is surer than that all the inventions, and improvements, and discoveries, of which our time is so fruitful, are tending with irresistible force to carry mere political democracy into anarchy.

All these evidences of growing social and political discontent, all these agitations and disturbances—the more violent talk on the one side, the leaning to repression on the other—are indications of unstable equilibrium, of a maladjustment of powerful forces. It is *the* necessity of the time—the vital, pressing necessity—that these phenomena receive the careful, conscientious attention of thoughtful men, who will trace them to their source and popularize the remedy. It will not do to leave them to the ignorant poor and the ignorant rich, to politicians and demagogues. They require the scientific spirit and the scientific method; they demand the thought of those who can think, and whose opinions carry weight.

THE INTERIOR OF THE EARTH.*

By R. RADAU.

II.

ASIDE from the evidences of the earth's internal heat furnished by artificial excavations, we have incontestable proof thereof in hot springs and in volcanic phenomena generally. The temperature of certain springs is nearly 100° at the surface. That of the Chaudes-Aigues is 80°; the Trincheras (Venezuela), 97°; the geysers of Iceland are 85° at the surface and 127° at a depth of twenty metres. But it is plain that the temperature of hot springs does not necessarily indicate the heat of the depths they come from. Aside from purely chemical agencies, there are physical causes sufficient to account for a very high degree of heat. When we consider the size of such caverns as those of Carniola and Istria, it will not be difficult to believe that there may be in the earth's crust fissures ten or twenty kilometres in depth, that may be filled with water, like the cavity that periodically absorbs and expels the water of the Lake of Kirknitz. Even at a depth of two or three kilometres the temperature of this water is 100°, but the pressure of two or three hundred atmospheres which it sustains prevents ebullition, as at 100° steam attains a pressure equal to the weight of only one atmosphere, and it does not form unless the pressure exceeds that. Under stronger pressure a higher temperature is required before ebullition takes place (i. e., the temperature at which the pressure of steam equals the resistance, or pressure on the liquid). Thus, under a

* Translated from the "Revue des Deux Mondes," by Guy B. Seely.

pressure of 10 atmospheres, water boils at 180° ; under 25 atmospheres at 225° ; beyond these limits the law that governs the phenomenon of ebullition is not accurately known, but it is known that the pressure of steam increases in a much more rapid ratio than the temperature, and it may be stated that it approximates to 1,200 atmospheres at about 600° ; 5,000 atmospheres at about 1,000°, etc. From this it is clear that there is a point where the pressure of steam will equal the weight, where consequently ebullition will occur. Admitting that the temperature of the soil increases at the rate of 1° to 20 metres, we would reach at twelve kilometres a temperature of 600° ; and at this depth the pressure of steam would equal the resistance. It would be necessary to go deeper if we adopt a less rapid rate of increase in temperature. Now, if water commences to boil beneath a certain level, the steam will rise through the mass and condense anew, as in a refrigerant imparting thereto a portion of its heat. The upper portion of the liquid will thus become heated more than the soil at the same level ; in fact, the water may boil even at the surface, as in the Iceland geysers.

If, in volcanic regions, the temperature is 1,000° at about twenty kilometres depth, the steam forming at that point may possess a pressure greater than 5,000 atmospheres—which would be sufficient to sustain the weight of a column of lava twenty kilometres high. At a temperature of 1,300° the pressure would doubtless be equal to 10,000 atmospheres. This is very nearly the force of the gas of gunpowder in a cannon of heavy caliber, and it is evident that this force would more than suffice for the mechanical effects of which volcanoes offer the terrifying spectacle.

However we view it, volcanoes are an irrefragable proof of a subterranean fire ; they truly seem to be the thousand gates of the burning hell we read of. The number of volcanoes discovered constantly increases with the progress of geographical knowledge ; in the least explored countries highly volcanic regions are found. A. von Humboldt enumerated 407, of which 227 were active. We now know of several thousand, and, according to M. Fuchs, the number of active volcanoes at the present time may be set down as 323. It is difficult to draw the line between active and extinct volcanoes, because the greater portion have periods of repose, possibly a century or more in length. We know that the ancients considered Vesuvius a perfectly harmless mountain up to the time of the great eruption of A. D. 79, when Herculaneum and Pompeii were buried, and that it remained quiet for three centuries (1306–1631).

On looking at a map whereon the volcanoes are marked as red points, the attention is at once struck by the fact that almost all are found in proximity to the large bodies of water. The greater number are found to be on islands ; and the remainder, with a very few exceptions, near the borders of the sea or of lacustrine basins. Around the

Pacific Ocean is a vast circle of ignivomous mountains — the western coasts of America, the Aleutian Islands, Kamtchatka, the Kuriles, Japan, the Philippines, Molucca, down to the Sunda Islands and New Zealand, being comprised therein. Aside from this immense belt only isolated groups are found, but they are always disposed around the borders of the sea, or near some large body of water. Does not this geographical distribution force us to the conclusion that there exists an intimate connection between volcanic phenomena and water? Shall not we say that infiltration of water is a necessary condition of eruptions, and that the force which expels the torrents of lava is due to the pressure of steam?

This view finds a confirmation in the recent discoveries of the chemical constitution of the gases emitted by volcanoes. According to M. Charles Sainte-Claire Deville, the clouds that emanate from volcanoes consist principally of the vapor of water. M. Fouqué estimated at over 2,000,000 cubic metres the quantity of water thrown out from Etna in a gaseous form during the eruption of 1865. The clouds of vapors issuing from a crater in eruption often condense and fall in deluge-like rains, which make torrents of mud of the volcanic ashes. The streams of lava are, moreover, so charged with vapors that they acquire a remarkable fluidity. These vapors are rapidly disengaged as the streams descend, and sometimes in suddenly escaping they occasion miniature eruptions in the middle of a torrent of solidifying lava. Marine salt and other elements of sea-water are found in the gaseous products of eruptions and in the deposits of fumaroles as well; and M. Fouqué's researches on the chemical composition of the emanations from Vesuvius, Etna, and the volcano of Santorin, show that they are in part the result of the decomposition of sea-water.

Such accumulated proofs no longer allow us to doubt the constant agency of water in the production of volcanic phenomena. It would seem that sea-water passes into the subterranean reservoirs either by percolation through fissures or by transudation under the enormous pressure it sustains. Coming in contact with the incandescent lava at a great depth, it is vaporized, and the accumulation of steam causes from time to time an explosion of these subterranean boilers. Although the heat of the lava-streams is rapidly dissipated by contact with the air, the temperature of the incandescent mass at the bottom of the crater may be estimated at 2,000°, for refractory metals are known to melt in contact with the molten lava. Were it not over 1,200°, the pressure of the steam generated by matter thus heated would be ample to account for the explosive force of eruptions. It is not necessary, indeed, to assume so great a depth as twenty kilometres for the seat of this force, in order to explain the existence of matter in fusion, for there is nothing to militate against the supposition that the earth's crust is thinner in volcanic regions than elsewhere. It is quite probable that the inner surface of this crust is furrowed and fissured, espe-

cially along the lines of unequal density where the continents join the ocean-beds.

The quantity of lava that a volcano emits during an eruption surpasses anything we can imagine. The volume of the lava-stream of Kilauea, in the great eruption of 1840, was estimated at five and a half milliards of cubic metres, and a still larger mass was thrown out in 1855 from the crater at the summit of Mauna Loa, of which Kilauea is the smaller outlet. But these are trifling compared with the mass of matter emitted by the Iceland volcano of Skapta-Jökull, in 1783, which was estimated to equal the volume of Mont Blanc, or not less than five hundred milliards of cubic metres! According to the probably exaggerated estimate of Zollinger, the total volume of scoriæ and ashes thrown out in 1815 from a volcano in the island of Sumbawa (Tomboro), to the distance of five hundred kilometres, equaled twice that of Mont Blanc. We have more exact data concerning the eruption of Coseguina, a small volcano of Central America, which, in 1835, rained pumice-stone on the land and sea over a radius of fifteen hundred kilometres, and discharged daily not less than fifty milliards of cubic metres. When we consider the stupendous force required to raise and throw to a distance such volumes of matter, it is difficult to believe that the underground forces that feed the volcanoes, and which we know have been active from a very remote period, are mere accumulations of matter in fusion. Still more difficult is it to suppose that the heat of these fires is due to chemical action developed in the bosom of the earth. We can not but seek, in the wide-spread, incandescent mass under the thin crust that varies, possibly, from twenty to one hundred kilometres in thickness, the proximate cause of volcanic phenomena. The objection based on the non-coincidence of eruptions of volcanoes situated in the same region disappears when the mechanism of the eruption is explained by the more or less fortuitous deposition of infiltrated water.

The question appears to be reduced to deciding whether the central nucleus on which the mass of lava rests is itself liquid or whether it is solid. This is a much disputed point, and great ingenuity has been shown on both sides of the argument. The hypothesis of a liquid nucleus has long been favored, and it has many adherents. It has been objected that a liquid nucleus would be subject to tides that would break in an instant the thin envelope and produce terrific cataclysms. Ampère, in particular, felt it impossible to reconcile this consequence of the hypothesis with the calm that reigns on the surface. "Those who maintain the idea of a liquid nucleus," said he, "do not appear to have considered the effect of the moon's attraction on this enormous liquid mass, which would cause tides analogous to those of our seas, but far more terrible, by reason of their extent and the density of the liquid. It is difficult to conceive how the earth's crust could withstand the action of a kind of hydraulic lever 1,400 leagues long."

He therefore maintained, with Davy, the hypothesis of a non-oxidized nucleus which becomes an inexhaustible chemical source of heat by contact with the already oxidized crust. In this view of the matter, a volcano is simply a permanent fissure and channel of intercourse between the non-oxygenated nucleus and the liquids lying upon the oxygenated bed. Whenever this passage of the liquids to the nucleus takes place, elevations of the earth occur from the increase of volume due to oxidation. The heat generated by these chemical actions is propagated at once toward the exterior and interior of the globe, and, in proportion as the oxidation of the crust progresses, the seat of these chemical actions is carried deeper. This, a difficult theory to sustain, has no longer any adherents.

To the objection of the power of the tides it may be further said that, examined more carefully, they would probably be found to produce an entirely inappreciable flexion of the solid crust far from sufficient to cause any disruption. Indeed, it is a question to be considered whether earthquake phenomena do not indicate the existence of subterranean tides. This is a matter that has formed the object of over thirty years' researches by M. Alexis Perrey, Professor of the Faculty of Sciences at Dijon. Professor Perrey has compiled all the observations of earthquakes from the middle of the last century to the present time, and, in grouping the various facts collected during these one hundred and twenty-five years, he has been able to adduce evidence of a connection between the frequency of earthquakes and the phases of the moon. If the phenomena are compared with the lunar month, two maxima will be seen at the periods of the syzigia (new and full moon), and two minima during the first and last quarter. In the following table the results of observations for three periods are given, the earthquake-days being grouped in the weeks corresponding to the moon's four phases, the new and full moon groups and the quadrature groups being separated:

OBSERVATIONS.	First Period. 1751-1800.	Second Period. 1801-1850.	Third Period. 1843-1872.
Total number of earthquakes	3,655	6,595	17,249
During the syzigia	1,901	3,434	8,838
During the quadratures	1,754	3,161	8,411
Difference in favor of syzigia	147	273	427

It would thus appear that the shocks occur more frequently at those periods when the sun and moon can combine their action on the liquid particles of the interior of the globe.

M. Perrey has also compared the earthquake-periods with the times of perigee and apogee, that is, the moon's nearest point in her orbit to

and farthest point from the earth. The following table gives the results of the comparison—periods of five days being taken—in the middle of which occurs a perigee or an apogee of the moon :

OBSERVATIONS.	1751-1801.	1801-1850.	1848-1878.
At perigee	526	1,223	3,290
At apogee	465	1,113	3,015
Difference in favor of perigee	61	110	275

A third means of ascertaining the moon's influence on earthquake phenomena consists in comparing the latter with the lunar day. There are then found to be two maxima corresponding to the moon's passage to the upper and lower meridian, or to what may be called the lunar mid-day and midnight. The minima occur near the middle of these intervals. M. Perrey has made comparisons in this way of 824 shocks felt at Arequipa from 1810 to 1845 ; of the journals of four observers at Monteleone, Messina, at Catanzaro and Scilla, in the years 1783 to 1785, which were marked by great eruptions of Vesuvius ; and, lastly, of the journal of M. S. Arcovito, kept at Reggio from 1836 to 1854. There is manifest, more or less markedly, in all these observations, a preponderance in favor of the hours of the moon's passing the meridian.

This constant increase in frequency of the shocks at the times when the tides are strongest would seem to prove that the producing cause extends its action below the earth's surface. The increase is small, it is true, but it is constantly apparent, however the facts may be viewed.

We must not lose sight of the local perturbations to which the irregularity of the earth's internal surface may give rise. As M. Perrey has said, the lower side of this shell must consist of curves and anfractuosities, mountains whose summits project into the central liquid like gigantic stalactites, and valleys which approach the outer surface. This internal orographic system must modify the propagation of the subterranean waves. As in narrow and rapid rivers, the waves will be confined, and will gain in power between two mountains that obstruct their passage ; they will spread out and lose power in a plain or valley whose configuration allows them to move more freely. Beating against cliffs and other obstructions, they will cause shocks and concussions, fissures, and a partial local falling of the internal vault, the effects of which will be felt at the surface as undulations and tremblings. All these causes combine to make of earthquakes a very complex phenomenon.

We might expect to find a species of tide-movement in the lava of active volcanoes, but data on this point are lacking. The only fact we have bearing upon it is derived from the observations of Scacchi and Palmieri during the eruption of Vesuvius in May, 1855, who noticed an

increase in the flow of the lava twice daily at intervals of about twelve hours' duration, and with a little less than an hour's retardation from one day to the next, as observed in the ocean-tides. The eruption commenced on the 1st of May, and the periodic swelling of the lava-stream was observed from the 5th to the 19th. Such observations could easily be made in the island of Hawaii, on the borders of the lava-lake of Kilauea.

It must not be forgotten that these subterranean tides do not by any means demonstrate the liquidity of the nucleus, but simply the existence of a liquid mass of a certain depth. It will be shown how astronomic phenomena furnish data for the solution of this question, but we will first glance at some purely physical considerations that have been advanced in elucidation of the matter.

Mr. James Thompson was the first to point out that compression would have the effect of lowering the point of fusion, and consequently of retarding the congelation of those liquids that expand in solidifying. This has been shown to be the case with water, and it would probably be found to be the same with iron. On the other hand, in the case of the far more numerous substances that contract in solidifying, compression facilitates congelation by cooling the mass. It ought, therefore, to raise the point of fusion, and this is known to occur with many bodies. Thus the melting-point of sulphur, which shrinks materially in solidifying, is raised from 107° to 140° under a pressure of eight hundred atmospheres. Now, according to the experiments of Bischof, the greater part of the rocks expand by fusion and contract in solidifying. Granite, the schists, and trachyte shrink about one fifth in solidifying. This tends to confirm the supposition, says Sir W. Thomson, that the earth's nucleus has long been solidified.

Let us conceive the earth as primarily wholly liquid. There would be established in the mass an equilibrium of temperature corresponding to a given pressure. As the mass cooled, solidification would commence, either on the surface or at the center. The question is a very complex one and can not be fully solved without a better knowledge than we have of the properties of the liquid under consideration. But assuming that solidification commences at the surface, a thin skin will first be formed, and this being by the hypothesis heavier than the liquid it covers—since its volume shrinks in solidifying—it follows that it must be broken up and the fragments be carried to the bottom or center, forming there a solid nucleus. Thus, in any event, solidification will occur at the center, and, when the entire mass has acquired a temperature near the point of solidification, a solid carapace will gradually cover the surface, beneath which here and there masses of liquid will still exist.

This argument, however, is open to question in several respects. M. Mallet's experiments, for instance, with the scoriæ of smelting-furnaces, show that certain silicates contract only six per cent. The

celebrated engineer, Werner Siemens, cites, as opposed to Sir W. Thomson's theory, the results of his experiments at the glass-works of his brother, Fr. Siemens, at Dresden. When the melted vitreous mass commenced to cool, contraction was at first very rapid, then more gradual as it attained a pasty consistency, and at the time of solidification it even seemed to expand slightly. From this M. Siemens concludes that the contraction resulting from the solidification of the fused silicates occurs during the change from the liquid to the pasty state; and, by Sir W. Thomson's reasoning, it would seem all the more probable that the central portions of the globe have already attained a pasty consistency.*

On the supposition that the solid crust has but a slight thickness, many phenomena are explained, notably the ascent of lava in volcanic vents, which might thus be due to the hydrostatic pressure caused by the weight of masses of rock. This same cause may even have contributed to the elevation of mountains, by forcing the lighter solid masses above the level of a sea of heavier lava. Again, the slow changes of level of the land, as seen in the changes in certain coast-lines, indicate a mobility of the solid crust, which would naturally experience oscillations in consequence of a secular displacement of its center of gravity, and this displacement may result from modifications of the exterior surface by the action of water, and of the inner surface by the action of lava. Indeed, do not earthquakes—whose cause may be found as well in the falling of masses of rock, or the action of subterranean waters, as in purely volcanic phenomena—constantly show that great changes are occurring in the depths of the ground?

Sir George Airy has lent the weight of his great authority to the hypothesis of a liquid nucleus, in his recent interesting address at Cockermouth, before an audience of miners and others. The illustrious astronomer royal holds the opinion that the earth's crust is formed of more or less compact rocks that float on a mass of fluid or semifluid lava. The heaviest of the rocks form the ocean-beds; lighter ones the continents; and the mountains are composed of the portions that project the farthest into the lava, in exactly the same way that large ships draw more water than small ones. It follows from this that beneath the mountains a considerable volume of relatively dense lava has been displaced by lighter masses, which would account for the slight effect produced by certain ranges—the Himalayas, for example—on the plummet.

Again, it is on the hypothesis of an internal fire that such theories of the elevation of mountains as that of M. Elie de Beaumont are founded. The earth's crust in cooling undergoes a contraction, causing ruptures on the arcs of great circles; the lava, as it is compressed by the contracting solidified crust, is forced through these fissures,

* "Physikalisch-mechanische Betrachtungen" ("Monatsbericht der Acad. der Wiss. zu Berlin," 1878).

folding back and elevating the edges, and forming, as it solidifies, long ridges which constitute the mountain-chains. The waters, displaced from their old beds, seek new basins, and, as a state of calm is reëstablished, they deposit the matter with which they become charged during the period of disturbance; and it is thus that sedimentary deposits, spreading over the more ancient disruptions, are formed. The existing configuration of the surface would thus be the resultant of a series of elevations separated by long intervals of time. The chronology of these occurrences M. de Beaumont has endeavored to establish by the aid of geometric laws, by virtue of which chains of contemporary formation assume a parallel direction. This theory of mountain upheavals has its weak features, especially that relating to the synchronism of its formations. It has been vigorously combated by the Sir Charles Lyell school, which attributes all the changes of the earth's surface to the slow action of forces that are still in operation about us. In considering the prodigious effects of volcanic eruptions and earthquakes, the secular oscillations of the ground, the changes of the earth's surface even in our day by the action of the sea and of rivers, the partisans of uniformity in geological changes reject the theory of cataclysms, as held by the opposite school. Still, it can not be denied that the earth has grown old, and that its energy must have diminished. On this point Sir W. Thomson makes a judicious remark: "It might be surprising but strictly admissible to assert that volcanic activity as a whole has never been more intense than at the present time. But it is not less certain that the earth contains to-day a smaller store of volcanic energy than it did a thousand years ago, as a ship of war, after a sharp engagement for five hours without replenishing its ammunition, contains less powder in its magazine than before the combat." Again, M. Charles Sainte-Claire Deville, in his lectures at the College of France, cited, in opposition to the uniformity theory, some considerations borrowed from an article of M. J. Bertrand's, on similitude in mechanism, from which it appears impossible, in accounting for a displacement of a given magnitude, to compensate for a deficit in energy by an indefinite extension of the time employed.

There is thus no lack of argument drawn from geognosy to sustain the hypothesis that changes in the earth are attributable to the mobility of the liquid nucleus; but we now pass to an examination of those furnished by astronomy.

Emanuel Swedenborg left behind him as a souvenir only a theosophy and a thaumaturgy; he was, however, a distinguished engineer, and before becoming the leader of a sect of visionaries, as the assessor of the Stockholm College of Mines published some researches that are not without value. In his great work of 1734 ("Principia Rerum Naturalium"), to which M. Nyren has recently called the attention of the scientific world, is for the first time elaborated a theory of the universe closely resembling the celebrated cosmogonic hypothesis of Laplace.

Swedenborg postulates a solar vortex, from which is gradually detached a ring, by the disruption of which the planetary globes and their satellites are formed.* Twenty years later analogous ideas were held by Immanuel Kant, who, it would seem, merely commented on and developed the views of Thomas Wright.† In this system the planets are formed directly by the condensation of nebulous matter without the intermediate formation of rings. These theories are curious in the light of the history of science. There is also the theory of Buffon, who imagined that a comet, striking the sun, forced from it a stream of matter that agglomerated to form the planets. But Laplace was the first to offer a theory of the origin of the solar system that was founded on rigorously scientific principles, and that conformed to the data of celestial mechanics. That which distinguishes the conceptions of his genius is, that the discoveries since made, far from weakening his hypothesis, seem on the contrary to daily strengthen it.

Laplace conceived all the stars formed by the gradual concentration of a nebulosity diffused in space, which became luminous in proportion as it condensed, under the force of gravitation. The sun itself was at first nebulous, with a brilliant nucleus. Supposing the system endowed with a rotary movement—and this is an unavoidable postulate—the solar atmosphere at first assumed a figure of spheroidal equilibrium, much flattened, and limited in its dimensions by the zone where the centrifugal force counterbalanced the weight. The molecules situated beyond this limit ceased to belong to the atmosphere proper, and revolved freely around the central star as planetary masses. Now, a law of mechanics teaches that in proportion as the cooling contracts the atmosphere and condenses the molecules in the vicinity of the nucleus, the rotation becomes more rapid; the centrifugal force thereby augmenting, the point where the weight counterbalances it is brought nearer the center, and the particles banished to the outskirts become planets. Contracting little by little, the solar atmosphere became separated from the zone of vapors in the plane of its equator. These abandoned vapors, wrecks of the solar ocean, must first have formed concentric rings circulating around the sun, comparable to the rings of Saturn. These rings would soon break up into several masses, which, speedily conglobulating, assumed a rotary movement in the direction of their revolution around the sun. It is thus that the planets originate, and give birth, in cooling, to the satellites that accompany them. "Hence," says Laplace, "the notable phenomenon of the slight eccentricity of the orbits of the planets and their satellites; of the slight inclination of these orbits to the plane of the solar equator; and of the identity of movement, in rotation and revolution, of all these bodies with that of the sun, giving to the hypothesis we offer a high degree

* The chapter is entitled "De chao universali solis et planetarum, deque separatione ejus in planetas et satellites."

† "An Original Theory or New Hypothesis of the Universe." London, 1750.

of verity." This also explains why the duration of the sun's rotation, twenty-five days, is less than that of the revolution of the various planets. And the triple ring of Saturn seems to be an ocular proof of the original extension of the atmosphere of that planet, and of its successive contractions. So many analogous phenomena certainly render Laplace's cosmogonic hypothesis highly probable.

A final confirmation of the theory is supplied by spectrum analysis. The study of the spectra of the nebulæ has demonstrated that, if many of them are merely agglomerations of stars, others are still gaseous bodies—veritable specimens of the primitive chaos, exemplifying perfectly Kant's, W. Herschel's, and Laplace's conception of the beginnings of worlds as they left the Creator's hands. Of the nebulæ two appear to be composed of a central globe with a ring like Saturn's, and in many others it seems possible to discern the gyratory movement by means of which planetary systems are formed.

Of recent investigations that have served to establish the basis and develop the results of Laplace's theory, we must place in the first rank the valuable researches of M. Edouard Roche, on the form of the heavenly bodies, which the author has recently supplemented by an essay on the constitution and origin of the solar system. M. Roche first demonstrates that by virtue of the particular form of the "free surface" bordering the atmosphere—a surface having a projecting ridge at the equator—as the nebula contracts a fluid stratum will slide from the poles toward the equator and be thrown off over the equatorial ridge as through an opening. It is thus that an equatorial zone, independent of the central body, will be formed and become an outer ring.

But the theory shows that *inner* rings will be formed from portions of the mobile matter brought toward the equator from the poles, and it is thus that Saturn's two inner rings would be formed, their radius being less than twice that of the planet. The equatorial extent of the planet's atmosphere being at present equal to 2, there can not have been a ring *thrown off* inside this distance. Laplace's theory, not admitting inner rings, accounts only for the formation of the largest of the three. M. Roche also holds that the moon was formed from an inner ring, and that it was developed in the bosom of the earth's atmosphere, which, withdrawing little by little, left its satellite free.

Every conception that favors Laplace's theory clearly tends to confirm the hypothesis of the earth's original fluidity, but without settling the question of the liquidity of the nucleus at the present time. Let us see to what extent this obscure question has been elucidated.

The equatorial swelling, which changes so slightly the spherical form of the globe, has nevertheless a very appreciable effect on the globe's rotation on its axis. If the earth were an exact sphere and entirely homogeneous, or if it were composed of homogeneous concentric spheres, the sun's attraction would have no effect on the move-

ment of rotation ; the axis of the earth would always remain parallel to itself—i. e., always point to the same place in the heavens ; but the sun's action on the equatorial protuberance gradually effects a change of direction in the earth's axis, and the moon produces an analogous effect. These perturbations constitute the phenomena of the precession of the equinoxes and nutation, by virtue of which the celestial pole is continually displaced among the stars.

It is from such considerations as these that Mr. Hopkins has drawn a serious argument against the fluidity of the earth's interior.* In considering the effect of the sun's and moon's action on the equatorial swelling, says Mr. Hopkins, we look upon the earth as a solid body, with all of its parts joined together, which ought to experience in its entirety the effects of these perturbing causes. But, if the earth is a liquid mass covered by a solid shell, these effects will be exerted only on the solid portion, which will in a manner slide on the liquid nucleus. As the perturbing forces will thus act on so small a portion of the globe, the effect on the rotary movement of the crust ought to be much greater than if the earth were viewed as a solid mass, and these forces will be the more intense in proportion as the crust is thin. In order to reconcile the possible effect of luni-solar action on the equatorial protuberance with the known amount of precession and nutation, Mr. Hopkins calculates the requisite thickness of the crust at not less than thirteen hundred to sixteen hundred kilometres, or from a fifth to a quarter of the earth's radius.

Mr. Hopkins's calculations were revised twenty years later by Sir W. Thomson in his "Memoir on the Rigidity of the Earth," † in which this illustrious physicist gives to Mr. Hopkins's views all the weight of his authority. "Whatever objection may be made to the mathematical portion of Mr. Hopkins's work," he says, "I can see no force in the reasoning employed to refute his conclusions, and I am happy to see my opinion in the matter confirmed by such an eminent authority as Archdeacon Pratt. It has, indeed, always seemed to me that Mr. Hopkins might have carried his argument further, and concluded that no completely liquid mass, approximating to a spheroid six thousand miles in diameter, can exist in the interior of the earth without being accompanied by a very different rate of precession and nutation from that which actually exists."

These arguments grew in favor with geologists, and the hypothesis of a liquid nucleus was gradually relegated to the limbo of superannuated prejudices, when the lamented M. Delaunay undertook to demolish the principal argument, and declared that in his opinion Mr. Hopkins's reasoning had no real foundation.‡ "To make clear our idea," said M. Delaunay, "let us take a glass globe filled with water.

* "Philosophical Transactions of the Royal Society," London, 1839–1842.

† Ibid., 1863.

‡ "Comptes rendus de l'Académie des Sciences," July, 1868.

If it is admitted that this liquid is endowed with an absolute fluidity, it is evident that, by giving the globe a brisk rotary movement on a vertical axis, it will turn without carrying the liquid around with it. This may be readily verified by giving it a more or less rapid movement of rotation. Light substances suspended in the water will appear to remain still, despite the ball's rotation. But will this always be the case, whatever the speed of rotation? If the globe were very slowly revolved, would the liquid still be unaffected by the movement of its envelope? In conceding the perfect fluidity of the liquid, its *viscosity* has been lost sight of. Now, this viscosity, though slight, is not *nil;* hence, if the rotation be sufficiently slow, the liquid will be carried around with the glass globe, the whole revolving as one piece, or solid ball." This rotation of the liquid under the conditions described has been demonstrated by M. Champagneur in a series of experiments undertaken, by request of M. Delaunay, in the laboratory of the Sorbonne.

Applying this reasoning to the earth, we will assume that it is composed of a liquid mass covered by a solid pellicle. It is first of all evident that, if we set aside the perturbations caused by the equatorial enlargement, the entire mass will turn as one piece on its axis; if any difference whatever could exist between the rate of the envelope's rotation and that of the nucleus, friction will speedily annul it. The perturbing influence of precession and nutation imparts to the solid envelope's proper movement of rotation an extremely slight acceleration. The question is, Does the internal liquid participate in this additional movement, or is the crust only affected by it? "As for me," says M. Delaunay, "there is no room for the slightest doubt. The acceleration due to the causes indicated is so slight that the fluid of the interior must follow the inclosing shell exactly as though the whole were a solid mass. So enormous is the pressure to which the various parts of the liquid mass are subjected that we can form no idea of its effect on the viscosity of the fluid in question. But if that fluid is in the condition of those we are familiar with, what we have described would occur." M. Delaunay concludes by stating that, in his opinion, the phenomena of precession and nutation can furnish no data concerning the greater or less thickness of the earth's crust.

Sir William Thomson again considers the question, and from a new point of view. In theoretically determining the height of the tides, the water only is supposed to yield to the luni-solar attraction—the solid shell of the earth being unaffected by it. Now, it is evident that even an entirely solid sphere will be slightly changed in form by these forces, and that the change will be still greater in a partially liquid sphere. We will first suppose that the entire mass of the globe yields to the attracting forces as readily as if it were liquid. In this case sea and solid land will be raised alike, and, the surface of the sea always being at the same distance from the bottom, no tides will be

seen. Granting that the average rigidity of the globe's mass is comparable to that of glass, we see that it must undergo a change of form equal to 0·6 of that which it would experience if it were liquid; and, deducting this elevation from the rise of the oceanic sheet, the height of the tide is not more than 0·4 of what it would be on a perfectly rigid ball.

Assuming the rigidity of the terrestrial mass to be that of steel, Sir W. Thomson estimates that it would still undergo a change from sphericity equal to one third of that of a liquid sphere, and the apparent height of the tides is thus found to be reduced to two thirds of that which would be produced on an absolutely rigid ball. Sir W. Thomson, while fully recognizing the uncertainty in which this question of the height of the tides rests, still deems it inadmissible that the actual height is only 0·4 of the theoretical height on the hypothesis of a globe of absolute rigidity. He accordingly concludes that our globe possesses a rigidity greater than that of glass, and perhaps than that of steel. Regarding the influence on the phenomena of precession and nutation due to the globe's elasticity, the deductions from the hypothesis of absolute rigidity accord with observation, and this would tend to confirm the conclusions drawn from the observations of the tides. Even if the variability of form tends directly to diminish the effect called precession, there still exists an indirect effect of this variation which tends to augment it, so that possibly these two contrary effects may nearly counterbalance each other.

Everything considered, it is not impossible to reconcile these conclusions with the existence of an intense heat in the central portions of the globe. It must not be forgotten that these central beds are subjected to a pressure increasing in intensity toward the center. By M. Roche's law of densities, we find that the pressure at the center exceeds 3,000,000 kilogrammes per square centimetre (3,000,000 atmospheres). We can form no idea of the physical condition of substances exposed to such a pressure. Experiments on the resistance of various substances have shown that small cubes of granite crumble under a weight of 700 atmospheres; basalt and porphyry under 2,000 and 2,500 atmospheres respectively. Under such pressure the rocks disintegrate and are pulverized. Copper, steel, and cast iron resist twice or thrice this pressure, but what will be the state of the metals under a pressure one hundred or one thousand times greater? What is the action of molecular forces, in solids or liquids, subjected to a pressure of several millions of atmospheres, and, at the same time, to a temperature of some thousand degrees? What *is* the solid or the liquid state under these conditions? Data on this point are absolutely lacking, and anything advanced thereon must be purely hypothetical. "We may compare mathematics," Professor Huxley aptly says, "to a mill of admirable construction, capable of grinding to any degree of fineness, but what comes from it depends upon what has been put into it, and, as the

most perfect mill conceivable will not produce flour if only pea-pods are put into it, pages on pages of formulæ will not give an exact result from inexact data."

ON THE METHOD OF ZADIG:

RETROSPECTIVE PROPHECY AS A FUNCTION OF SCIENCE.

By Professor T. H. HUXLEY.

"Une marque plus sûre que toutes celles de Zadig."—Cuvier.*

IT is a usual and a commendable practice to preface the discussion of the views of a philosophic thinker by some account of the man and of the circumstances which shaped his life and colored his way of looking at things; but, though Zadig is cited in one of the most important chapters of Cuvier's greatest work, little is known about him, and that little might perhaps be better authenticated than it is.

It is said that he lived at Babylon in the time of King Moabdar; but the name of Moabdar does not appear in the list of Babylonian sovereigns brought to light by the patience and the industry of the decipherers of cuneiform inscriptions in these later years; nor indeed am I aware that there is any other authority for his existence than that of the biographer of Zadig, one Arouet de Voltaire, among whose most conspicuous merits strict historical accuracy is perhaps hardly to be reckoned.

Happily Zadig is in the position of a great many other philosophers. What he was like when he was in the flesh, indeed whether he existed at all, are matters of no great consequence. What we care about in a light is that it shows the way, not whether it is lamp or candle, tallow or wax. Our only real interest in Zadig lies in the conceptions of which he is the putative father; and his biographer has stated these with so much clearness and vivacious illustration that we need hardly feel a pang, even if critical research should prove King Moabdar and all the rest of the story to be unhistorical, and reduce Zadig himself to the shadowy condition of a solar myth.

Voltaire tells us that, disenchanted with life by sundry domestic misadventures, Zadig withdrew from the turmoil of Babylon to a secluded retreat on the banks of the Euphrates, where he beguiled his solitude by the study of nature. The manifold wonders of the world of life had a peculiar attraction for the lonely student; incessant and patient observation of the plants and animals about him sharpened his naturally good powers of observation and of reasoning; until, at

* "Discours sur les Révolutions de la Surface du Globe," "*Recherches sur les Ossemens fossiles*," ed. iv, t. i, p. 185.

length, he acquired a sagacity which enabled him to perceive endless minute differences among objects which, to the untutored eye, appeared absolutely alike.

It might have been expected that this enlargement of the powers of the mind and of its store of natural knowledge could tend to nothing but the increase of a man's own welfare and the good of his fellow men. But Zadig was fated to experience the vanity of such expectations.

One day, walking near a little wood, he saw, hastening that way, one of the queen's chief eunuchs, followed by a troop of officials, who appeared to be in the greatest anxiety, running hither and thither like men distraught, in search of some lost treasure.

"Young man," cried the eunuch, "have you seen the queen's dog?" Zadig answered modestly, "A bitch, I think, not a dog." "Quite right," replied the eunuch; and Zadig continued: "A very small spaniel who has lately had puppies; she limps with the left foreleg, and has very long ears." "Ah! you have seen her, then?" said the breathless eunuch. "No," answered Zadig, "I have not seen her; and I really was not aware that the queen possessed a spaniel."

By an odd coincidence, at the very same time, the handsomest horse in the king's stables broke away from his groom in the Babylonian plains. The grand huntsman and all his staff were seeking the horse with as much anxiety as the eunuch and his people the spaniel; and the grand huntsman asked Zadig if he had not seen the king's horse go that way.

"A first-rate galloper, small-hoofed, five feet high; tail three feet and a half long; cheek-pieces of the bit of twenty-three carat gold; shoes silver?" said Zadig.

"Which way did he go? Where is he?" cried the grand huntsman.

"I have not seen anything of the horse, and I never heard of him before," replied Zadig.

The grand huntsman and the chief eunuch made sure that Zadig had stolen both the king's horse and the queen's spaniel, so they haled him before the high court of Desterham, which at once condemned him to the knout and transportation for life to Siberia. But the sentence was hardly pronounced when the lost horse and spaniel were found. So the judges were under the painful necessity of reconsidering their decision; but they fined Zadig four hundred ounces of gold for saying that he had seen that which he had not seen.

The first thing was to pay the fine; afterward Zadig was permitted to open his defense to the court, which he did in the following terms:

"Stars of justice, abysses of knowledge, mirrors of truth, whose gravity is as that of lead, whose inflexibility is as that of iron, who rival the diamond in clearness, and possess no little affinity with gold; since I am permitted to address your august assembly, I swear by Ormuzd that I have never seen the respectable lady dog of the queen, nor beheld the sacrosanct horse of the King of kings.

"This is what happened: I was taking a walk toward the little wood near which I subsequently had the honor to meet the venerable chief eunuch and the most illustrious grand huntsman. I noticed the track of an animal in the sand, and it was easy to see that it was that of a small dog. Long faint streaks upon the little elevations of sand between the foot-marks convinced me that it was a she-dog, with pendent dugs—showing that she must have had

puppies not many days since. Other scrapings of the sand, which always lay close to the marks of the fore-paws, indicated that she had very long ears; and, as the imprint of one foot was always fainter than those of the other three, I judged that the lady dog of our august queen was, if I may venture to say so, a little lame.

"With respect to the horse of the King of kings, permit me to observe that, wandering through the paths which traverse the wood, I noticed the marks of horseshoes. They were all equidistant. 'Ah!' said I, 'this is a famous galloper.' In a narrow alley, only seven feet wide, the dust upon the trunks of the trees was a little disturbed at three feet and a half from the middle of the path. 'This horse,' said I to myself, 'had a tail three feet and a half long, and, lashing it from one side to the other, he has swept away the dust.' Branches of trees met overhead at the height of five feet, and under them I saw newly fallen leaves; so I knew the horse had brushed some of the branches and was therefore five feet high. As to his bit, it must have been made of twenty-three carat gold, for he had rubbed it against a stone, which turned out to be a touchstone, with the properties of which I am familiar by experiment. Lastly, by the marks which his shoes left upon pebbles of another kind, I was led to think that his shoes were of fine silver."

All the judges admired Zadig's profound and subtile discernment; and the fame of it reached even the king and the queen. From the anterooms to the presence-chamber, Zadig's name was in everybody's mouth; and, although many of the magi were of the opinion that he ought to be burned as a sorcerer, the king commanded that the four hundred ounces of gold which he had been fined should be restored to him. So the officers of the court went in state with the four hundred ounces; only they retained three hundred and ninety-eight for legal expenses, and their servants expected fees.

Those who are interested in learning more of the fateful history of Zadig must turn to the original; we are dealing with him only as a philosopher, and this brief excerpt suffices for the exemplification of the nature of his conclusions and of the method by which he arrived at them.

These conclusions may be said to be of the nature of retrospective prophecies; though it is perhaps a little hazardous to employ phraseology which perilously suggests a contradiction in terms—the word "prophecy" being so constantly, in ordinary use, restricted to "foretelling." Strictly, however, the term prophecy as much applies to outspeaking as to foretelling; and, even in the restricted sense of "divination," it is obvious that the essence of the prophetic operation does not lie in its backward or forward relation to the course of time, but in the fact that it is the apprehension of that which lies out of the sphere of immediate knowledge; the seeing of that which to the natural sense of the seer is invisible.

The foreteller asserts that, at some future time, a properly situated observer will witness certain events; the clairvoyant declares that, at this present time, certain things are to be witnessed a thousand miles away; the retrospective prophet (would that there were such a word as "backteller"!) affirms that, so many hours or years ago, such and

such things were to be seen. In all these cases it is only the relation to time which alters—the process of divination beyond the limits of possible direct knowledge remains the same.

No doubt it was their instinctive recognition of the analogy between Zadig's results and those obtained by authorized inspiration which inspired the Babylonian magi with the desire to burn the philosopher. Zadig admitted that he had never either seen or heard of the horse of the king or of the spaniel of the queen; and yet he ventured to assert in the most positive manner that animals answering to their description did actually exist, and ran about the plains of Babylon. If his method was good for the divination of the course of events ten hours old, why should it not be good for those of ten years or ten centuries past; nay, might it not extend to ten thousand years, and justify the impious in meddling with the traditions of Oannes and the fish, and all the sacred foundations of Babylonian cosmogony?

But this was not the worst. There was another consideration which obviously dictated to the more thoughtful of the magi the propriety of burning Zadig out of hand. His defense was worse than his offense. It showed that his mode of divination was fraught with danger to magianism in general. Swollen with the pride of human reason, he had ignored the established canons of magian lore; and, trusting to what after all was mere carnal common sense, he professed to lead men to a deeper insight into nature than magian wisdom, with all its lofty antagonism to everything common, had ever reached. What, in fact, lay at the foundation of all Zadig's arguments but the coarse, commonplace assumption upon which every act of our daily lives is based, that we may conclude from an effect to the preëxistence of a cause competent to produce that effect?

The tracks were exactly like those which dogs and horses leave; therefore they were the effects of such animals as causes. The marks at the sides of the fore-prints of the dog-track were exactly such as would be produced by long, trailing ears; therefore the dog's long ears were the causes of these marks—and so on. Nothing can be more hopelessly vulgar, more unlike the majestic development of a system of grandly unintelligible conclusions from sublimely inconceivable premises, such as delights the magian heart. In fact, Zadig's method was nothing but the method of all mankind. Retrospective prophecies, far more astonishing for their minute accuracy than those of Zadig, are familiar to those who have watched the daily life of nomadic people.

From freshly broken twigs, crushed leaves, disturbed pebbles, and imprints hardly discernible by the untrained eye, such graduates in the University of Nature will divine, not only the fact that a party has passed that way, but its strength, its composition, the course it took, and the number of hours or days which have elapsed since it passed. But they are able to do this because, like Zadig, they per-

ceive endless minute differences where untrained eyes discern nothing; and because the unconscious logic of common sense compels them to account for these effects by the causes which they know to be competent to produce them.

And such mere methodized savagery was to discover the hidden things of nature better than *a priori* deductions from the nature of Ormuzd—perhaps to give a history of the past, in which Oannes would be altogether ignored! Decidedly it were better to burn this man at once.

If instinct, or an unwonted use of reason, led Moabdar's magi to this conclusion two or three thousand years ago, all that can be said is that subsequent history has fully justified them. For the rigorous application of Zadig's logic to the results of accurate and long-continued observation has founded all those sciences which have been termed historical or palætiological, because they are retrospectively prophetic and strive toward the reconstruction in human imagination of events which have vanished and ceased to be.

History, in the ordinary acceptation of the word, is based upon the interpretation of documentary evidence; and documents would have no evidential value unless historians were justified in their assumption that they have come into existence by the operation of causes similar to those of which documents are, in our present experience, the effects. If a written history can be produced otherwise than by human agency, or if the man who wrote a given document was actuated by other than ordinary human motives, such documents are of no more evidential value than so many arabesques.

Archæology, which takes up the thread of history beyond the point at which documentary evidence fails us, could have no existence, except for our well-grounded confidence that monuments and works of art, or artifice, have never been produced by causes different in kind from those to which they now owe their origin. And geology, which traces back the course of history beyond the limits of archæology, could tell us nothing except for the assumption that, millions of years ago, water, heat, gravitation, friction, animal and vegetable life, caused effects of the same kind as they do now. Nay, even physical astronomy, in so far as it takes us back to the uttermost point of time which palætiological science can reach, is founded upon the same assumption. If the law of gravitation ever failed to be true, even to the smallest extent, for that period, the calculations of the astronomer have no application.

The power of prediction, of prospective prophecy, is that which is commonly regarded as the great prerogative of physical science. And truly it is a wonderful fact that one can go into a shop and buy for small price a book, the "Nautical Almanac," which will foretell the exact position to be occupied by one of Jupiter's moons six months hence; nay, more, that, if it were worth while, the Astronomer Royal

could furnish us with as infallible a prediction applicable to 1980 or 2980.

But astronomy is not less remarkable for its power of retrospective prophecy.

Thales, oldest of Greek philosophers, the dates of whose birth and death are uncertain, but who flourished about 600 B. C., is said to have foretold an eclipse of the sun which took place in his time during a battle between the Medes and the Lydians. Sir George Airy has written a very learned and interesting memoir * in which he proves that such an eclipse was visible in Lydia on the afternoon of the 28th of May, in the year 585 B. C.

No one doubts that, on the day and at the hour mentioned by the Astronomer Royal, the people of Asia Minor saw the face of the sun totally obscured. But, though we implicitly believe this retrospective prophecy, it is incapable of verification. It is impossible even to conceive any means of ascertaining directly whether the eclipse of Thales happened or not. All that can be said is, that the prospective prophecies of the astronomer are always verified; and that, inasmuch as his retrospective prophecies are the result of following backward the very same method as that which invariably leads to verified results when it is worked forward, there is as much reason for placing full confidence in the one as in the other. Retrospective prophecy is therefore a legitimate function of astronomical science; and if it is legitimate for one science it is legitimate for all; the fundamental axiom on which it rests, the constancy of the order of nature, being the common foundation of all scientific thought. Indeed, if there can be grades in legitimacy, certain branches of science have the advantage over astronomy, in so far as their retrospective prophecies are not only susceptible of verification, but are sometimes strikingly verified.

Such a science exists in that application of the principles of biology to the interpretation of the animal and vegetable remains imbedded in the rocks which compose the surface of the globe, which is called paleontology.

At no very distant time, the question whether these so-called "fossils" were really the remains of animals and plants was hotly disputed. Very learned persons maintained that they were nothing of the kind, but a sort of concretion or crystallization which had taken place within the stone in which they are found; and which simulated the forms of animal and vegetable life, just as frost on a window-pane imitates vegetation. At the present day it would probably be impossible to find any sane advocate of this opinion; and the fact is rather surprising that among the people from whom the circle-squarers, perpetual-motioners, flat-earth men, and the like, are recruited, to say

* "On the Eclipses of Agathocles, Thales, and Xerxes," "Philosophical Transactions," vol. cxliii.

nothing of table-turners and spirit-rappers, somebody has not perceived the easy avenue to nonsensical notoriety open to any one who will take up the good old doctrine that fossils are all *lusus naturæ*.

The position would be impregnable, inasmuch as it is quite impossible to prove the contrary. If a man choose to maintain that a fossil oyster-shell, in spite of its correspondence, down to every minutest particular, with that of an oyster fresh taken out of the sea, was never tenanted by a living oyster, but is a mineral concretion, there is no demonstrating his error. All that can be done is to show him that, by a parity of reasoning, he is bound to admit that a heap of oyster-shells outside a fishmonger's door may also be "sports of Nature," and that a mutton-bone in a dust-bin may have had the like origin. And when you can not prove that people are wrong, but only that they are absurd, the best course is to let them alone.

The whole fabric of paleontology, in fact, falls to the ground unless we admit the validity of Zadig's great principle, that like effects imply like causes; and that the process of reasoning from a shell, or a tooth, or a bone, to the nature of the animal to which it belonged, rests absolutely on the assumption that the likeness of this shell, or tooth, or bone to that of some animal with which we are already acquainted, is such that we are justified in inferring a corresponding degree of likeness in the rest of the two organisms. It is on this very simple principle, and not upon imaginary laws of physiological correlation, about which, in most cases, we know nothing whatever, that the so-called restorations of the paleontologist are based.

Abundant iliustrations of this truth will occur to every one who is familiar with paleontology; none is more suitable than the case of the so-called *Belemnites*. In the early days of the study of fossils, this name was given to certain elongated stony bodies, ending at one extremity in a conical point, and truncated at the other, which were commonly reputed to be thunderbolts, and as such to have descended from the sky. They are common enough in some parts of England; and, in the condition in which they are ordinarily found, it might be difficult to give satisfactory reasons for denying them to be merely mineral bodies.

They appear, in fact, to consist of nothing but concentric layers of carbonate of lime, disposed in subcrystalline fibers, or prisms, perpendicular to the layers. Among a great number of specimens of these Belemnites, however, it was soon observed that some showed a conical cavity at the blunt end; and, in still better preserved specimens, this cavity appeared to be divided into chambers by delicate, saucer-shaped partitions, situated at regular intervals one above the other. Now, there is no mineral body which presents any structure comparable to this, and the conclusion suggested itself that the Belemnites must be the effects of causes other than those which are at work in inorganic

nature. On close examination, the saucer-shaped partitions were proved to be all perforated at one point, and, the perforations being situated exactly in the same line, the chambers were seen to be traversed by a canal or *siphuncle*, which thus connected the smallest or apical chamber with the largest. There is nothing like this in the vegetable world; but an exactly corresponding structure is met with in the shells of two kinds of existing animals, the pearly *Nautilus* and the *Spirula*, and only in them. These animals belong to the same division—the *Cephalopoda*—as the cuttle-fish, the squid, and the octopus. But they are the only existing members of the group which possess chambered, siphunculated shells; and it is utterly impossible to trace any physiological connection between the very peculiar structural characters of a cephalopod and the presence of a chambered shell. In fact, the squid has, instead of any such shell, a horny "pen," the cuttle-fish has the so-called "cuttle-bone," and the octopus has no shell at all, or a mere rudiment of one.

Nevertheless, seeing that there is nothing in nature at all like the chambered shell of the Belemnite, except the shells of the *Nautilus* and of the *Spirula*, it was legitimate to prophesy that the animal from which the fossil proceeded must have belonged to the group of the *Cephalopoda*. *Nautilus* and *Spirula* are both very rare animals, but the progress of investigation brought to light the singular fact that, though each has the characteristic cephalopodous organization, it is very different from the other. The shell of *Nautilus* is external, that of *Spirula* internal; *Nautilus* has four gills, *Spirula* two; *Nautilus* has multitudinous tentacles, *Spirula* has only ten arms beset with horny rimmed suckers; *Spirula*, like the squids and cuttle-fishes, which it closely resembles, has a bag of ink which it squirts out to cover its retreat when alarmed; *Nautilus* has none.

No amount of physiological reasoning could enable any one to say whether the animal which fabricated the Belemnite was more like *Nautilus*, or more like *Spirula*. But the accidental discovery of Belemnites in due connection with black elongated masses which were certainly fossilized ink-bags, inasmuch as the ink could be ground up and used for painting as well as if it were recent sepia, settled the question; and it became perfectly safe to prophesy that the creature which fabricated the Belemnite was a two-gilled cephalopod with suckers on its arms, and with all the other essential features of our living squids, cuttle-fishes, and *Spirulæ*. The paleontologist was, by this time, able to speak as confidently about the animal of the Belemnite as Zadig was respecting the queen's spaniel. He could give a very fair description of its external appearance, and even enter pretty fully into the details of its internal organization, and yet could declare that neither he, nor any one else, had ever seen one. And, as the queen's spaniel was found, so happily has the animal of the Belemnite; a few exceptionally preserved specimens having been discovered which com-

pletely verify the retrospective prophecy of those who interpreted the facts of the case by due application of the method of Zadig.

These Belemnites flourished in prodigious abundance in the seas of the mesozoic or secondary age of the world's geological history; but no trace of them has been found in any of the tertiary deposits, and they appear to have died out toward the close of the mesozoic epoch. The method of Zadig, therefore, applies in full force to the events of a period which is immeasurably remote, which long preceded the origin of the most conspicuous mountain masses of the present world and the deposition, at the bottom of the ocean, of the rocks which form the greater part of the soil of our present continents. The Euphrates itself, at the mouth of which Oannes landed, is a thing of yesterday compared with a Belemnite; and even the liberal chronology of magian cosmogony fixes the beginning of the world only at a time when other applications of Zadig's method afford convincing evidence that, could we have been there to see, things would have looked very much as they do now. Truly the magi were wise in their generation; they foresaw rightly that this pestilent application of the principles of common sense inaugurated by Zadig would be their ruin.

But it may be said that the method of Zadig, which is simple reasoning from analogy, does not account for the most striking feats of modern paleontology—the reconstruction of entire animals from a tooth or perhaps a fragment of a bone; and it may be justly urged that Cuvier, the great master of this kind of investigation, gave a very different account of the process which yielded such remarkable results.

Cuvier is not the first man of ability who has failed to make his own mental processes clear to himself, and he will not be the last. The matter can be easily tested. Search the eight volumes of the "Recherches sur les Ossemens fossiles" from cover to cover, and no reasoning from physiological necessities—nothing but the application of the method of Zadig pure and simple—will be found.

There is one well-known case which may represent all. It is an excellent illustration of Cuvier's sagacity, and he evidently takes some pride in telling his story about it. A split slab of stone arrived from the quarries of Montmartre, the two halves of which contained the greater part of the skeleton of a small animal. On careful examinations of the characters of the teeth and of the lower jaw, which happened to be exposed, Cuvier assured himself that they presented such a very close resemblance to the corresponding parts in the living opossum that he at once assigned the fossil to that genus.

Now, the opossums are unlike most mammals, in that they possess two bones attached to the fore part of the pelvis, which are commonly called "marsupial bones." The name is a misnomer, originally conferred because it was thought that these bones have something to do with the support of the pouch, or marsupium, with which some, but

not all, of the opossums are provided. As a matter of fact, they have nothing to do with the support of the pouch, and they exist as much in those opossums which have no pouches as in those which possess them. In truth, no one knows what the use of these bones may be, nor has any valid theory of their physiological import yet been suggested. And, if we have no knowledge of the physiological importance of the bones themselves, it is obviously absurd to pretend that we are able to give physiological reasons why the presence of these bones is associated with certain peculiarities of the teeth and of the jaws. If any one knows why four molar teeth and an inflected angle of the jaw are almost always found along with marsupial bones, he has not yet communicated that knowledge to the world.

If, however, Zadig was right in concluding from the likeness of the hoof-prints which he observed to a horse's that the creature which made them had a tail like that of a horse, Cuvier, seeing that the teeth and jaw of his fossil were just like those of an opossum, had the same right to conclude that the pelvis would also be like an opossum's; and so strong was his conviction that this retrospective prophecy about an animal which he had never seen before, and which had been dead and buried for millions of years, would be verified, that he went to work upon the slab which contained the pelvis in confident expectation of finding and laying bare the "marsupial bones," to the satisfaction of some persons whom he had invited to witness their disinterment. As he says: "Cette opération se fit en présence de quelques personnes à qui j'en avais annoncé d'avance le résultat, dans l'intention de leur prouver par le fait la justice de nos théories zoologiques; puisque le vrai cachet d'une théorie est sans contredit la faculté qu'elle donne de prévoir les phénomènes."

In the "Ossemens fossiles," Cuvier leaves his paper just as it first appeared in the "Annales du Muséum," as "a curious monument of the force of zoölogical laws and of the use which may be made of them."

Zoölogical laws truly, but not physiological laws. If one sees a live dog's head, it is extremely probable that a dog's tail is not far off, though nobody can say why that sort of head and that sort of tail go together; what physiological connection there is between the two. So in the case of the Montmartre fossil, Cuvier, finding a thorough opossum's head, concluded that the pelvis also would be like an opossum's. But, most assuredly, the most advanced physiologist of the present day could throw no light on the question why these are associated, nor could pretend to affirm that the existence of the one is necessarily connected with that of the other. In fact, had it so happened that the pelvis of the fossil had been originally exposed, while the head lay hidden, the presence of the "marsupial bones," however like they might have been to an opossum's, would by no means have warranted the prediction that the skull would turn out to be that of the opossum.

It might just as well have been like that of some other marsupial; or even like that of the totally different group of Monotremes, of which the only living representatives are the *Echidna* and the *Ornithorhynchus*.

For all practical purposes, however, the empirical laws of coördination of structures which are embodied in the generalizations of morphology may be confidently trusted, if employed with due caution, to lead to a just interpretation of fossil remains; or, in other words, we may look for the verification of the retrospective prophecies which are based upon them.

And, if this be the case, the late advances which have been made in paleontological discovery open out a new field for such prophecies. For it has been ascertained with respect to many groups of animals, that, as we trace them back in time, their ancestors gradually cease to exhibit those special modifications which at present characterize the type, and more nearly embody the general plan of the group to which they belong.

Thus, in the well-known case of the horse, the toes which are suppressed in the living horse are found to be more and more complete in the older members of the group, until, at the bottom of the Tertiary series of America, we find an equine animal which has four toes in front and three behind. No remains of the horse-tribe are at present known from any Mesozoic deposit. Yet who can doubt that, whenever a sufficiently extensive series of lacustrine and fluviatile beds of that age becomes known, the lineage which has been traced thus far will be continued by equine quadrupeds with an increasing number of digits, until the horse type merges in the five-toed form toward which these gradations point?

But the argument which holds good for the horse holds good, not only for all mammals, but for the whole animal world. And as the study of the pedigrees or lines of evolution to which at present we have access brings to light, as it assuredly will do, the laws of that process, we shall be able to reason from the facts with which the geological record furnishes us to those which have hitherto remained, and many of which, perhaps, may for ever remain hidden. The same method of reasoning which enables us, when furnished with a fragment of an extinct animal, to prophesy the character which the whole organism exhibited, will, sooner or later, enable us, when we know a few of the later terms of a genealogical series, to predict the nature of the earlier terms.

In no very distant future, the method of Zadig, applied to a greater body of facts than the present generation is fortunate enough to handle, will enable the biologist to reconstruct the scheme of life from its beginning, and to speak as confidently of the character of long extinct living beings, no trace of which has been preserved, as Zadig did of the queen's spaniel and the king's horse. Let us hope that they

may be better rewarded for their toil and their sagacity than was the Babylonian philosopher; for perhaps, by that time, the magi also may be reckoned among the members of a forgotten fauna, extinguished in the struggle for existence against their great rival common sense.—*Nineteenth Century.*

THE MEDICINAL LEECH.

By Dr. A. BERGHAUS.

MANY swamps and ponds, which are now considered utterly worthless, might be made sources of great profit by devoting them to the production of a worm which is exceedingly valuable, and the cultivation of which requires no expensive outlay. This worm is the medicinal leech; formerly esteemed of no value, and hated and hunted on account of its bloodthirstiness, it has commanded extremely high prices since its useful qualities have been recognized. Its general appearance is familiar, its internal structure is very wonderful. Its body forms a cylindrical sac, composed of a course of about one hundred rings. The terminal ring of the hinder part is broader and stouter than the others, and serves as a foot. At the front extremity, which is more pointed than the hinder part, are two fine, separated lips, which, when brought together, form a closed ring. Several straight lines run along the back for the whole length of the body, while the belly is of a clearer color and is mottled with irregular dark spots. The body of the leech is so elastic that it can stretch itself out to a length of nearly ten inches, and draw itself up again to within the dimensions of an olive. Within and back of the lips are three thick membranous pads covered with a thin, horny mass bearing several rows of microscopic teeth; they may be described as the jaws. Between the jaws passes the very narrow throat, which can be opened and closed at will by means of a transverse muscle. The animal derives its importance to man from the close aggregation of the movable lips, the narrow throat, and the toothed jaws, for it is enabled by this peculiarity to break through the skin and suck the blood from it. The mechanical operation is as follows: When the lips close in a circle upon the air-tight skin, the jaws are also brought down to it and their saw-like teeth are pressed tight upon the cuticle. The throat having now become fast closed, the head of the worm is drawn back a little, and the lips are thereby given the form of an exhausted cupping-glass, which is divided internally, by the jaws still fastened to the skin, into three distinctly separated parts. The skin is powerfully sucked up into these three divisions of the cupping apparatus till it is torn, and rents are formed corresponding to the three spaces between the jaws, the inner ends of which run into each other and form a larger,

still three-parted wound. It follows that the sucking of the leech must be without effect on the hairy parts of the body, where a cupping-glass could not be made air-tight, and this is the case. When the space between the skin and lips, which answers to the interior of the cupping-glass, is filled with blood, the throat is opened, the blood is drawn

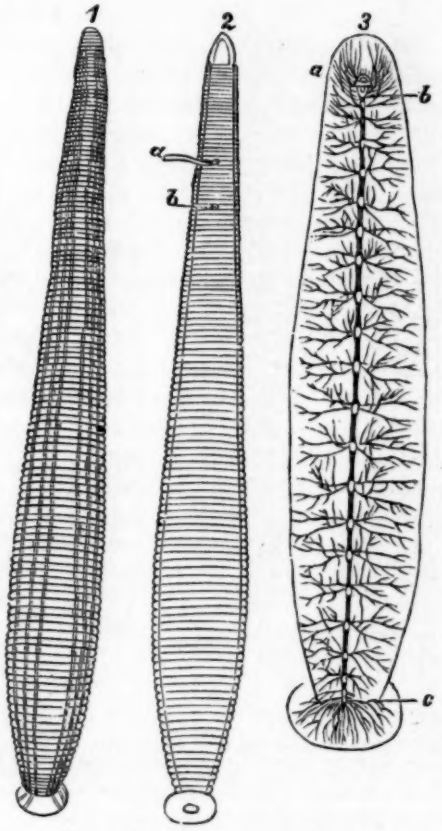


FIG 1—1. THE MEDICINAL LEECH (*Hirudo medicinalis*) seen from above. 2. The same, under side; *a b*, sexual organs. 3. The nervous cord with its ramifications: *a*, forward upper part; *b*, forward lower part; *c*, posterior nervous node.

by sucking movements of the body into the maw, and the mouth of the worm is filled anew with blood. The long, narrow maw is competent, by means of twenty-six peculiarly formed sacs or valves, which are arranged in two rows, to retain an immense quantity of blood without any of it being driven back by the muscular activity of the body; and, if a hole is pricked in the body of the leech at the rear end of the maw, all the blood that has been sucked up may be made to flow out. On account of the narrowness of its throat, the leech can not take solid food. Its usual nourishment consists of animal and vegetable infusoria,

which it swallows in masses as the whale does herrings; and while the whale spouts out through its nose the water it has swallowed and only retains the herring, the leech exudes the excess of water by means of a peculiar glandular apparatus in its skin, and keeps the infusoria in its maw. It also readily drinks the blood of cold-blooded and warm-

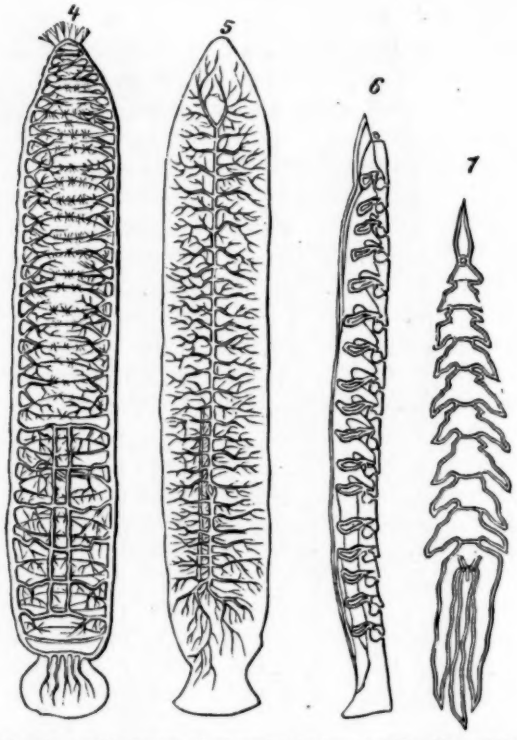


FIG. 2—4. Arterial system, with the principal vessels (or heart) at the side, and their ramifications. 5. Venous system. 6. The intestinal canal, seen from the side; the round slime-sacs, or breathing-bladders, are situated between the folds of the maw. 7. The intestinal canal, seen from above: the upper part is the throat; the other parts represent the maw and intestines.

blooded animals, and fills itself so greedily with the latter that it can not endure the surfeit, and dies soon afterward. Leeches were formerly abundant in the bogs and ponds of Germany, where, by reason of their great fruitfulness, they increased to millions, and were considered so worthless, even noxious, that the owners of the lands permitted the traveling dealers to fish them out at first for nothing, afterward for a small price. Finally the ponds were cleared of them; the dealers had sold the leeches for an immense profit, and millions on millions of them had been exported from Hamburg to America, and wherever else this costly and irreplaceable medical apparatus was needed, while the land of its production had none. The useful leech is not found in all countries, but its abode is limited to central Europe, Asia Minor, and a

small part of the northern coast of Africa. In some of these relatively confined regions it has been exterminated. The demand for it has become very great; France and Germany, for example, use about thirty million, and the exportation from Hamburg alone has been thirty million in a year.* It is not surprising that so important a demand has raised the price of leeches till they have become a very profitable article of trade.

The successful stocking of a pond with leeches is a work requiring considerable care; the animal has many enemies, against which it must be protected, and will not thrive except under specially favorable conditions. The mother-leeches, when planted in the pond, lay their cocoons (which contain the eggs) as in nature, and the young brood is hatched out at the proper time; but this brood, besides protection, requires its natural food, sickens if it does not find it, and can not be fed artificially. The young worms will not thrive in artificial ponds; neither can they be transplanted from other countries and left to themselves without having first undergone a process of acclimatization. The most suitable ponds for acclimatizing leeches should be dug in bog-lands to a depth of about six feet, and should have from about six to ten inches of bog-soil on the bottom. The pond should contain about three feet of water, and should be provided with an inflow of fresh water and be surrounded with a wall two or three feet high. If the leeches are put in the pond in May or June, they will deposit their cocoons toward September in funnel-shaped holes in the peaty bottom; in the course of a few days some ten or fifteen young

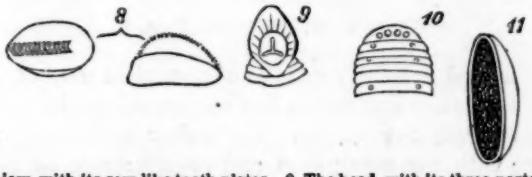


FIG. 8.—8. The jaw, with its saw-like tooth-plates. 9. The head, with its three-parted mouth opening. 10. The upper side of the head, with ten eyes. 11. Section of a cocoon with its eggs.

leeches will come out from the cocoon, and will attach themselves to the old one to suck from it till they are large enough to seek food for themselves. For food, the pond should be furnished with calamus and other reed-like plants; and duck-weed, little fishes, snails and frogs should be put into it. Toward the latter part of the fall the animals

* Although the application of leeches has been diminished in consequence of the adoption of new practices in medicine, which permit bloodletting only in a limited degree, the use of the animal is still considerable, and always will be so. A few years ago, when bloodletting played an important part in sickness, leeches enough could not be got, and it was hard to satisfy the demand in the ordinary way. Five to six million leeches, costing a million and a half of francs, were used in the hospitals of Paris yearly from 1829 to 1836, and 187,000 pounds of blood were drawn annually, or 1,496,000 pounds in the eight years!

should be taken out of the propagating pond and put into a smaller pond with a solid bottom of clear loam or sand, from which they may be taken in the spring to the marshes and bogs, in which, from that time, they will increase quite rapidly.

The question whether leeches can be cultivated on a large scale with profit may be answered decisively in the affirmative by pointing to a few examples in which the business has been carried on successfully. The brothers Béchade hired a large swamp from Baron Pichon, near Bordeaux, as grass-land, for a rent of three hundred francs; after stocking it with leeches they were able to have the rent gradually raised to 25,000 francs without feeling overcharged. Since they began their enterprise, in 1835, leech-culture has risen at Bordeaux to be a source of great profit, involving the application of 5,000 hectares (12,500 acres) of land to the purpose, employing a great many workmen, and representing a capital of several million francs. A landowner in Mecklenburg is said to receive an income of not less than 18,000 marks ($4,284) from his share of the rent of a leech-farm. A physician at Liegingen, in Würtemberg, stocked a marsh of two and a half hectares (six and a quarter acres) with leeches in 1827, and succeeded so well with it that he was able to sell his worms by the hundred-weight.—*Translated from Die Natur.*

RECENT ORIGINAL WORK AT HARVARD.

By J. R. W. HITCHCOCK, A. B.

SOME able and scholarly articles appeared in one of the leading New York dailies during the last winter, comparing Harvard with the principal universities abroad. The writer evidenced his thorough acquaintance with the curriculum and requirements at Harvard, but the original work done there outside the lecture-room was almost completely ignored, and dismissed with hardly a passing mention. This would tend to confirm the impression of the great majority that a university is simply a vast class-room, a place where young men study and recite certain time-honored branches of learning, varying their intellectual labors by feats of physical prowess, and are rewarded at the end of a specified time with mysterious parchment rolls, currently supposed to possess a subtile and awful power. Of the higher aims of a university, and of the distinction between *instructors* and *investigators*, the public at large realize almost nothing.

With a view to showing the inner intellectual activity of a university, I recently visited Harvard studies and laboratories to ascertain what work was being carried on aside from the regular routine of instruction. The spirit that prevails among the gentlemen with whom

I was brought in contact is aptly illustrated by the words of Mill, quoted to me by one of the professors:

"If we were asked for what end, above all others, endowed universities exist, or ought to exist, we should answer: To keep alive philosophy. . . . To educate common minds for the common business of life, a public provision may be useful but is not indispensable."

And after these words followed a strong commendation of a plan for allowing each professor one year in three for independent original research. The wisdom of this becomes evident when we remember that the endowments of the professorships were, with one exception, given for the promotion of teaching. No research fund exists, and aside from the stated work of the university many of the instructors devote a portion of their time to private instruction, which has greatly increased since the success of the recent efforts to have women methodically instructed at Cambridge by Harvard professors. These drains upon the time and energy of the professors render it the more surprising and creditable that so much original research is being constantly carried on in the different departments of the university.

I have only aimed at noting the principal features of the original work carried on, in general, during the year. In some cases it was impossible to dissociate the researches upon which investigators were engaged at the time of my visit from preceding work, but anything like entering into details or giving a modified historical sketch has been utterly impracticable. This will be better appreciated by any one who has seen the catalogue of books and memoirs published by Harvard professors from 1865 to 1875, prepared under the direction of President Eliot in 1875, but unfortunately so printed by the Commissioner of Education as to be valueless for purposes of comparison.

While I acknowledge that my article is necessarily superficial and incomplete, I yet trust it may be found to possess a certain value as giving a view of the highest and yet least known side of the intellectual life of a university.

Professor W. W. Goodwin, at the head of the Greek department, has been recently preparing a new edition of his well-known grammar, and has also been engaged upon several articles on Attic law, Athenian antiquities, and Greek particles for the new edition of Liddell and Scott's lexicon, which is to be republished by Harper & Brothers. An article from the pen of Professor Goodwin recently appeared in Professor Gildersleeve's "Philological Magazine" on a matter of Athenian law. In this connection American scholars will be interested in knowing that Professor Goodwin's "Grammar" and his "Moods and Tenses" have been reprinted in England, and a recent visitor to Oxford spoke to me of seeing these books lying on the tables of Oxford dons and bearing the marks of frequent use.

The amount of Greek required of all students at Harvard has been gradually reduced during the past twenty-five years, until Greek

scholars have recognized the fact that, for the department to hold its own, it would be necessary to substitute for the old plan of reading a given amount of Greek, the ability to read Greek readily at sight. To meet this new demand, Professor J. W. White is engaged in preparing a word-book, based on Curtius's Etymology, and not on the more or less untrustworthy etymologies of the lexicon. This book is to contain five or six hundred stems, from which five or six thousand words are to be derived in families, with their Latin and English cognates. This word-book is intended as a direct means of acquiring a vocabulary and facility in reading at sight, and, so far as I know, is entirely a new departure. Professor White is also revising the "First Greek Lessons," which is to be an accompaniment to the new edition of Goodwin's Grammar. He is assisted by the members of a graduate elective—a somewhat novel feature at Cambridge—who are pursuing advanced studies in Greek.

The traditional Latin grammar has become a thing of the past, and, in consequence, college students are daily found ignorant on many points, especially questions of comparative philology, that should have been answered in the schools. In order to furnish a more thorough and satisfactory groundwork for men who are fitting for college, Professor Lane is preparing a Latin grammar which will be based on new and scientific principles. It will be a thoroughly practical book, and, while not dealing directly with questions of comparative philology, will elucidate the important principles of the science.

Professor Greenough, whose name is familiarly known in connection with Allen and Greenough's Latin text-books, is preparing an edition of Vergil.

Since the publication of his "Modern Philosophy" Professor Bowen has been engaged in revising his "Political Economy," a new edition of which will appear in the fall. A volume of his essays is now in press. Within the last year he has written some important papers for the "North American" and "Princeton" Reviews, one of the most remarkable of which is "The Idea of Cause," which appeared in the "Princeton Review" for May, 1879, and has been republished separately.

Professor James is engaged upon a work on psychology, which is to form one of the series of American science text-books. Among his recent writings are articles in "Mind," "The Journal of Speculative Philosophy," "The Popular Science Monthly," and an essay in the "Princeton Review" on the "Sentiment of Rationality."

Perhaps the work that will prove most generally interesting is that upon which Professor Childs is now engaged—a book of English and Scottish ballads, with their derivations and variations. His life-long devotion to this subject, together with his mastery of English literature, will render this book perhaps the most valuable literary production of the year. It is owing to his efforts and researches that the

Harvard library contains the richest collection of literature pertaining to folk and ballad lore in the world.

In connection with original work by students, Professor Hill has introduced a new elective, which consists of oral discussions on given subjects that the students investigate for themselves in the library.

In the department of modern languages, Professor Cook is editing and preparing articles for a French and English lexicon, to be published by Hachette & Co., of Paris. Mr. Sheldon, instructor in German, has recently completed a German grammar.

No course of electives in the university offers a broader and richer field for true culture than those in fine arts, which, though of comparatively recent institution, have been so conducted as to be firmly placed on an enduring footing. Professor Norton, the head of this department, is preparing a book on "Historical Studies of Church-Building in the Middle Ages," which will probably appear within a few months. Assistant Professor Moore, who has recently returned from abroad, brought with him a number of exceedingly instructive copies and drawings made by himself, which serve as an important basis for the art-collection that, it is to be hoped, will be gathered together in connection with this department. The work of the Art Club also deserves mention. This is an association of students, with the coöperation of professors, who meet fortnightly for the discussion of art subjects, and to listen to lectures. The club has recently had two exhibitions, one of Professor Moore's collection, and one of Whistler's etchings, and has printed some valuable contributions to art-literature.

At the time of my visit to Professor Paine he was writing the "Spring Symphony," which has since been produced at a university concert in Sanders's Theatre, and at a Harvard symphony concert in Boston. Among the best known works that Professor Paine has composed of late years are his oratorio "St. Peter," the overture to "As You Like It," brought out by Thomas, the "Centennial Hymn," and a symphony in C minor.

The tendency of the practical mind to judge a man's work by its tangible results leads to a lack of appreciation and a total underrating of the work done by the faithful laborers in the field of *pure* as distinguished from *applied* science. An Edison outdoes the telegraph, or dazzles the world with the electric light, and the gaping crowd who bow before the successful inventor forget that he has simply applied principles and laws discovered long before by silent workers in studies and laboratories, who have toiled on comparatively unknown, amply rewarded by the knowledge that their life-work has added to the world's store of scientific truth. The scientific work of a university, fruitful though it may be in discoveries, is generally under-estimated, because true *savants* the world over feel no interest in turning the results of their work into the practical form of dollars

and cents. And so at Harvard the investigations constantly going on in the chemical and physical laboratories, at the Botanic Garden, Agassiz's Museum, and the Observatory, though resulting almost daily in the discovery of new truths, are hardly calculated to awaken popular interest or enthusiasm.

The labors of Professor Benjamin Peirce, the head of the mathematical department, are too extensive to admit of more than a passing mention here. In addition to his private mathematical, physical, and astronomical work, he has entered the field of philosophy in his recent lectures on the connection between religion and science.

In the last publication of the American Academy of Arts and Sciences, in which, by the way, seven of the eight papers are by Harvard investigators, appear the following "Propositions in Cosmical Physics," by Professor Benjamin Peirce:

1. All stellar light emanates from superheated gas. Hence the sun and stars are gaseous bodies.

2. Gaseous bodies, in the process of radiating light and heat, condense and become hotter throughout their mass.

3. It is probable that their surface would become colder if there were not an external supply of heat from the collision of meteors.

4. Large celestial bodies are constantly deriving superficial heat from the collision of meteors, till at length the surface becomes superheated gas, which constitution must finally extend through the mass.

5. Small celestial bodies are constantly cooling till they become invisible solid meteors.

6. The heat of space consists of two parts: first, that of radiation principally from the stars, which is small, except in the immediate vicinity of the stars; the second portion is derived from the velocity with which the meteors strike the planet at which the observation is taken; and this velocity partly depends upon the mass of the star by which the orbit of the planet is defined, and partly upon the mass of the planet itself.

7. If the planets were originally formed by the collision of meteors, it is difficult to account for an initial heat sufficient to liquefy them, and, at the same time, to account for their subsequent cooling without a great change in the number and nature of the meteors; and any such hypothesis seems to invalidate the meteoric theory.

8. If the planets were not originally formed by the collision of meteors, their common direction of rotation becomes difficult of explanation.

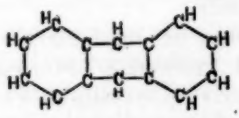
Professor J. M. Peirce has recently published a set of "Mathematical Tables," in which the part relating to "Hyperbolic Functions" is entirely original. Other work in this department is represented by Professor Byerly's "Differential Calculus" and Mr. Wheeler's "Elementary Plane and Spherical Trigonometry."

The forbidding granite building called "Boylston Hall" conceals scenes of strange activity. Unwonted odors irritate the inexperienced

nose of the visitor, and in the laboratories spectral shapes flit backward and forward behind clouds of vapor, occasionally lit up by lurid flames. These are the students; but in their private laboratories the professors pursue their own researches. Professor Cooke has been dealing with that unprincipled element, antimony, which has obdurately persisted in claiming two atomic weights, until he has successfully limited it to one. In connection with his laboratory-work, Professor Cooke is preparing a new edition of his "Chemical Philosophy." The results of his inorganic work have appeared from time to time in the publications of the Academy of Arts and Sciences.

Since the "Organic Laboratory" was established, in 1875, Professors Hill and Jackson have published twenty-five papers giving the results of their work, and have discovered one hundred new compounds. The discovery of new compounds, however, possesses as a rule no special importance, and is rather incidental to, than the result of, the main work. Two examples will indicate somewhat the character and object of organic investigations. The *composition* of uric acid has been long known to be $C_5H_4N_4O_3$, but its *constitution*—the exact arrangement of the atoms—has been uncertain. Chemists all over the world had endeavored to settle the question, but their failures resulted in eleven different formulæ for this one substance. Professor Hill, taking this uric acid, $C_5H_4N_4O_3$, marked one part by replacing H by CH_3 (methyl); then treating the acid so as to split it up, he determined to which part the methyl was attached, and, by continuing his treatment, was enabled to reduce the possible formulæ from eleven to three, with strong probabilities in favor of one. This possesses a practical value, inasmuch as it will lead to a knowledge of the method of formation of uric acid in the animal body. Professor Hill's work on "Fur-ferrol," found in the products of the distillation of wood, is interesting, as chlorophyll can probably be obtained from it.

An example of the curious subtilties of science is afforded by Professor Jackson's investigations of anthracene, which is obtained from coal-tar, and yields alizarine (madder-dye), used in dyeing pink and purple calicoes, Turkey reds, etc. Anthracene was known to consist of two hexagons of carbon with hydrogen-atoms attached, united by two other carbon-atoms. Professor Jackson proved, by making anthracene artificially, that these two carbon-atoms are united to adjacent corners in each hexagon, thus:



These are but stray examples of the researches that are constantly being made by Professors Hill, Jackson, and their assistants. Brombenzylbromides, parachlorbenzyls, and benzaldehyds, however, fasci-

nating as they may be to chemists, would offer few charms to the general reader.

Since 1841 Dr. Asa Gray has devoted such leisure as he could command to his great work "The Flora of North America," a labor the magnitude of which only an experienced botanist can appreciate. Mr. Watson, Curator of the Herbarium, is assisting Professor Gray, and at present is classifying the flora of California. The new series of botanical text-books, edited by Dr. Gray, will shortly be completed. The titles will be as follows :

1. "Structure and Morphological Botany of Phænogamous Plants," by Dr. Gray.

2. "Physiological Botany" (Vegetable Histology and Physiology), by Dr. Goodale.

3. "Introduction to Cryptogamous Botany," by Professor Farlow.

4. "Natural Orders of Phænogamous Plants and their Special Morphological Classification, Distribution, Products," by Dr. Gray.

One of the most recent of Dr. Gray's botanical contributions to the Academy of Arts and Sciences was a paper on the "Characters of some New Species of Compositæ in the Mexican Collection, made by C. C. Parry and Edward Palmer," and a notice of "Some New North American Genera, Species, etc."

Professor Farlow's work in cryptogamic botany is doubly interesting on account of its direct practical application. At the Bussey Institution Professor Farlow has been investigating the diseases of plants, and latterly has been engaged upon algæ and fungi. Among his recent work is a paper on algæ for the United States Fish Commission, an examination of the causes of onion-smut and the diseases of trees for the Board of Agriculture, and an investigation of the algæ producing disagreeable tastes and smells in water, for the State Board of Health. His work resolves itself, speaking generally, into two kinds —one, the abstract descriptions and arrangements in families of algæ and fungi, and the other the detection of fungi in disease. As an example of the first, there is a European species of algæ which constitutes the green scum on stagnant water. Several different varieties may be found in different places, but they have all been discovered to belong to the same family. To illustrate the second, there is a certain kind of fungus on cedar-trees, but this has been ascertained to be only a first stage, and the fungus in its second stage is found upon several members of the apple family.

Professor Wolcott Gibbs has been carrying on researches on complex inorganic acids, and Professors Lovering and Trowbridge have been conducting purely physical investigations. Professor Trowbridge has introduced a method of instruction that necessitates a large amount of original research on the part of his students. This consists of lectures, given by the students instead of by the instructor, to the class. Although all the work at the Observatory really comes under the

head of original investigation, the observations constantly taken in connection with the Observatory Time Service resolve themselves into mere routine work. An immediate and practical benefit is conferred by this Time Service, the signals of which reach Bangor, Lennoxville, in Canada, Albany, and New York, as well as different points in Massachusetts. The copper time-ball, held by a powerful electro-magnet at the top of the mast on the Equitable Life Assurance Building, Boston, is released at noon by the clock at Cambridge. During 1879 accidents caused a small error in its fall on two days only, and on three days it has been dropped at 12h. 5m. 0s.

The great equatorial of fifteen inches' aperture and the meridian circle whose telescope has an aperture of eight inches have been kept actively in use for the last three years. The former instrument has been devoted almost entirely to photometric work. The problem of astronomical photometry, roughly stated, is to determine the brightness of all the heavenly bodies, so that all may be compared with a single standard. Previous to the beginning of this work at the Harvard Observatory, photometric measurements had been made almost entirely upon the planets and brighter stars, and there was no definite knowledge of the amount of light emitted by the satellites and fainter stars. At the outset of the work several hundred measurements were taken of the brightness of the outer and inner satellites of Mars, which measures have been taken accurately nowhere else. The satellites of Jupiter and Saturn, including Hyperion, the faintest of Saturn's satellites, were similarly measured. In addition to measuring their brightness, a large number of determinations of the positions of the satellites were made. A comparison was also begun of the light of the sun and stars, with the idea of reducing all photometric measurements to a common standard—the light of the sun. This photometric work has been continued until the light of all the known satellites, except the two inner satellites of Uranus, has been measured.

One of the most important series of equatorial observations has been in connection with the eclipses of Jupiter's satellites. These phenomena have proved exceedingly valuable as a means not only of determining the orbits of the satellites themselves, but of measuring the distance of the sun or the velocity of light, and of obtaining terrestrial longitudes.

The observations of the mere appearance or disappearance of a satellite, however, can not be rendered sufficiently exact, and, to lessen the errors, photometric observations have been made of the satellites as they gradually enter or emerge from the shadow of Jupiter, using the planet itself or another satellite as a standard.

In order to furnish means for the comparison of the scales of stellar magnitude, employed by different astronomers in their estimate of the brightness of faint stars, a number of faint stars in the immediate neighborhood of the north pole were selected for photometric mea-

surement, and a circular was distributed among astronomers requesting estimates of magnitudes of the same stars for comparison with each other, and with the results of the measurements made here. A series of measurements of all the planetary nebulæ has also been undertaken. This work with the great equatorial has necessitated the invention of a number of new photometric instruments, which have been devised by Professor Pickering and his assistants.

For nearly eight years Professor Rogers has been engaged upon one of the largest astronomical undertakings that has been successfully completed in this country. This is the observation with the meridian circle of the zone of eight thousand stars, between fifty and fifty-five degrees north, undertaken by this Observatory as its share in the determination of the position of the stars of the northern hemisphere. The observations were finished about a year ago, but some years will be required to complete the reduction and publication of this work.

The total number of observations for 1879 with the meridian circle, including about six hundred for the Coast Survey, was nearly three thousand. The scientists at the Observatory are now engaged in the task of determining the light of all the stars visible to the naked eye in the latitude of Cambridge. The meridian is used in observations like a transit instrument in connection with a new and elaborately designed photometer.

At the Museum of Comparative Zoölogy the staff of specialists is almost entirely occupied in the classification and arrangement of different collections and the publication of the results of their researches. The most important accessions during 1878 and 1879 are the extensive collections of the Blake dredging expedition, and the collections of birds, mammals, reptiles, and fishes, made by Mr. Garman at St. Kitts, Dominica, Grenada, Trinidad, St. Thomas, and Porto Rico, after he left the Blake. The Blake collections and specimens from the entomological, conchological, and ornithological departments are in the hands of well-known specialists for final investigation. Of the extensive work in progress it is impossible to give any details. The results are embodied in the extensive publications of the museum. Five volumes of bulletins have been published, averaging about a dozen papers each. The quarto publications will hereafter be issued as memoirs. The catalogues thus far published have been collected into Volumes I.–IV. of the memoirs. Five volumes of memoirs and the first part of the sixth have already appeared. The second part of the sixth and Vol. VII. are now in course of preparation or in press. Vol. VI. contains the great work upon which Professor Whitney is now engaged, "The Auriferous Gravels of the Sierra Nevada of California." The Sturgis Hooper Professorship of Geology, held by Professor Whitney, is noticeable as being founded solely for original research.

The dredging operations of the Coast Survey steamer Blake have not only aided zoölogical science by the information obtained in regard

to echini, corals, crinoids, ophiurians, worms, hydroids, and others, but have added to geographical knowledge of the Caribbean Sea by showing the changes in form and distribution of lands along various groups of islands, and in the form of the land beneath the water. Professor Agassiz considers the deep-sea collections of the Blake the largest and most important ever made on this coast, and, when combined with the results of other expeditions sent out under the auspices of the Coast Survey, they make the collections at the museum but little inferior to those of the Challenger. During the coming summer Professor Agassiz will probably undertake another dredging trip in the Blake, following the course of the Gulf Stream to the north of the Bahamas, and dredging from the 100- to the 2,500- fathom line off the coast of the United States, so as to connect the isolated district with the deep-water fauna proper of the Atlantic.

Professor N. S. Shaler, Professor of Paleontology, in addition to his work at the museum, and as an instructor, has, since 1873, had charge of the Kentucky State Survey. Four volumes of reports and one of memoirs have been already completed, and one volume of memoirs and nine of reports are now in press. The recent writings of Professor Shaler are "The Origin and Nature of Intellectual Property," and several articles in the "Proceedings of the Boston Natural History Society," "The Atlantic Monthly," and "The International Review." The article by Professor Shaler in the latter magazine is entitled "Sleep and Dreams."

Scientific publications, based entirely or in part upon the entomological collection of the museum, are the new edition of the "Catalogue of the Diptera of the United States," by Osten-Sacken, published by the Smithsonian Institution, Part VIII. of the "Monographic Revision of the European Trichoptera," by R. McLachlan, published in London, and several papers by Dr. H. A. Hagen, the head of the department.

The recent work of Professor Langdell, Dean of the Lower School, is peculiarly rich and important. It includes a "Summary of Equity Pleading," a new edition of "Cases on Contracts," containing a summary of the law of contracts as developed in these cases, and a book on the "Law of Sales."

Professor Ames is engaged upon a work to be entitled "Bills and Notes," and Professor Thayer is at work upon a book on "Evidence."

Aside from his duties as professor in the Divinity School, Professor Abbot is a member of the American committee which assists the English Commission for revising the translation of the Bible. He is also a contributor to "The Unitarian Review," in which he has lately published a series of articles on "The Authorship of the Fourth Gospel," which are masterpieces of critical scholarship.

Mr. Allen is preparing a new edition of his "Hebrew Men and Times," and is also engaged upon a book of "Latin Composition."

During the administration of Mr. Winsor, some new features have been introduced into the management of the library, which, though hardly coming under the head of original work, are important and interesting. At intervals of a week or less, printed lists are struck off of the books received, and posted up for reference. These are collected and published monthly. A quarterly bulletin is issued, containing valuable bibliographical contributions by members of the faculty and the librarian. The most important publication of last year was the "Catalogue of Scientific Serials from 1633–1876," an octavo volume of three hundred and seventy pages, by Mr. S. H. Scudder, the entomologist, who is assistant librarian. This book constitutes Vol. I. of the special publications of the library.

The instructors in the various departments indicate the books which their students will need to consult frequently, and all such books are reserved and placed in special alcoves where they can be freely consulted during library hours. One or two advanced classes meet and work at the library in the midst of the reference-books bearing on their subjects. The tendency of this method necessarily is to excite a spirit of investigation in the student, and, to a good degree, students as well as professors pursue original research.

It would seem unfair to leave Cambridge without a glance at the beautiful gymnasium, the lack of which was so long a heavy cross for Harvard students.

The medical director has devised various new and yet wonderfully simple forms of apparatus for strengthening the muscles of the neck, back, loins, and abdomen, as well as of the arms and legs. A physical examination and carefully supervised gradation of exercise distinguish the new era of Harvard muscular Christianity from the old.

At the medical school the largest amount of original investigation is carried on in the physiological and chemical laboratories. In the former a number of new forms of apparatus are in use, which have been designed by Professor Bowditch and his assistants. Among these are an apparatus for keeping animals alive by artificial respiration; a dog-holder, canulæ for observations on the vocal cords of animals, without interfering with their natural respiration; unpolarizable electrodes used in studying certain problems in the physiology of the nervous system, a new form of apparatus for barometric measurements, and a novel plan for measuring the volume of air inspired and expelled in respiration. A new form of plethysmograph has been devised by Dr. Bowditch. This is an instrument for measuring the changes in the size of organs, either hollow or solid, which are produced by variations in the conditions to which they are subjected. The essential part of Dr. Bowditch's invention is a contrivance by which fluid is allowed to flow freely to and from the organ to be measured without changing its absolute level in the receptacle into which it flows, while

at the same time a record is made of the volume of the fluid thus displaced.

The more important work going on in the laboratory at the time of my visit consisted of experiments in regard to respiration, with special reference to the functions of the glottis and epiglottis, and trials of disinfectants with a view to ascertaining the temperature necessary to kill germs. A series of experiments was also in progress for testing the porosity of various stones used in building.

The results of the original work performed here have been recently published, together with an account of the physical apparatus in use at the school. Accounts of the most important investigations carried on during the last year are contained in the following papers: "Growth as a Function of Cells: Preliminary Notice of Certain Laws of Histological Differentiation," by C. G. Minot; "Effects of the Respiratory Movements on the Pulmonary Circulation," by H. P. Bowditch, M. D., and G. M. Garland, M. D.; "Pharyngeal Respiration," by G. M. Garland, M. D.; "Functions of the Epiglottis in Deglutition and Phonation," by G. L. Walton. This paper shows that the removal of the epiglottis does not seriously affect deglutition, and therefore it is not necessary for that process. The epiglottis, however, plays an important part in forming and modifying the voice, taking different positions during vocalization, changes of pitch, quality, and intensity.

In the chemical laboratory I found that Professor Wood had been examining the water-supply of Cambridge; and was then engaged in the investigation of the extent to which arsenic is being used in the manufacture or ornamentation of articles in general use, such as wall-paper, confectionery, playthings, etc. The results of this work will be published in the next report of the State Board of Health. Professor Wood is also writing the addition to "Ziemssen's Cyclopædia" on the subject of toxicology.

Dr. William B. Hills was engaged upon a special investigation in regard to the localization of arsenic in the animal economy.

The most important feature of original work at the school of late years has been Dr. Bigelow's introduction of the new operation of litholapaxy.

A number of interesting papers have been recently written by members of the faculty, some of which contain new discoveries of considerable scientific importance. I cite two: "Effects of Certain Drugs in increasing or diminishing Red Blood-Corpuscles," by Dr. Cutter; and "Alterations in the Spinal Cord in Hydrophobia," by Dr. Fitz.

The School of Agriculture and Horticulture, called "The Bussey Institution," is located on the sunny slopes of Forest Hills, about five miles southwest from Boston. The labors of the professors connected with this institution have been even more in the line of original research than of instruction, though of late the lack of a sufficient endow-

ment has interfered with the quantity of work and the publication of the results.

A number of exceedingly interesting and valuable papers, however, have appeared in the "Bussey Bulletin," the titles of which give some indication of the character of the work. I give a few of the more important: "Hybridization of Lilies," by Professor Parkman; "Diseases caused by Fungi"—Professor Farlow; "Examinations of Fodders," "Trials of Fertilizers," Prominence of Carbonate of Lime in Soil-Water," "Importance as Plant-Food of the Nitrogen in Vegetable Mold"—Professor F. H. Storer; "The Potato-Rot," and "The Black Knot" (of plum- and cherry-trees)—Professor Farlow.

The Bussey Institution ends my outline of the original work that has been carried on among Harvard professors mainly during the last year. Purely literary work I have endeavored to avoid, but I may say, in passing, that Dr. O. W. Holmes has recently finished an elaborate examination of the life and writings of Jonathan Edwards. Another feature worthy of special attention is the growing tendency with instructors to develop original research among the students. This is particularly noticeable in the departments of political economy, physics, history, and in some of the electives in mathematics. The case-system in the Law School is the purest example of an effort to cultivate independent thought. Mere memorizing is becoming by degrees a matter of secondary importance, and instructors are aiming to train their pupils to think for themselves, and to pursue lines of investigation outside of the beaten routine-path. Necessarily, the attainment of this result must prove in the highest degree beneficial. The cultivation of the powers of perception and insight becomes of inestimable value in fitting the student for the successful accomplishment of the duties of real life. As yet only a beginning has been made in training students to independent habits of thought, but this may fairly be considered the forerunner of a promising future. With the development of a thorough system of physical culture and the growth and prevalence of original investigation rather than memorizing for examinations, the Harvard student may perhaps obtain the ideal liberal education, when "his body is the ready servant of his will, and does with ease and pleasure all the work that as a mechanism it is capable of; his intellect is a clear, cold, logic-engine, with all its parts of equal strength, and in smooth working order—ready, like a steam-engine, to be turned to any kind of work."

The original work of the instructors, hastily sketched in this article, speaks for itself, and needs no word of explanation or commentary. That so much should be accomplished, however, outside of routine-work is indeed surprising and creditable, when we consider that the primary duty of these professors is an advanced teaching which absorbs both time and energy. It becomes evident that a life of scholastic seclusion is neither a life of monotonous drill-work nor

one of dilettant leisure, and it is clear that American scholarship can no longer be called unproductive. Comparisons inevitably suggest themselves. Harvard possesses a larger number of professors engaged in independent research than any other institution in the country, and to Harvard, I believe, belongs the honor of leading all American universities in original work.

GEOLOGY AND HISTORY.

By Professor GRANT ALLEN.

THE science of human life has been the last to recognize that minute interaction of all the sciences which every other department of knowledge now readily admits. We allow at once that no man can be a good physiologist unless he possesses a previous acquaintance with anatomy and chemistry. The chemist, in turn, must know something of physics, while the physicist can not move a step until he calls in the mathematician to his aid. Astronomy long appeared to be an isolated study, requiring nothing more than geometrical and arithmetical skill; but spectrum analysis has lately shown us its intimate interdependence upon chemistry and experimental physics. Thus the whole circle of the sciences has become a continuous chain of cycles and epicycles, rather than a simple sequence of unconnected and independent principles.

History, however, still stands to a great extent outside the ever-widening sphere of physical philosophy. It is comparatively seldom that we see an historian like Dr. Curtius acknowledging the interaction of land and people upon one another's character and destiny. More often we find even the modern annalist writing in the spirit of Mr. Freeman, as though men and women formed the only factors in the historical problem, and the great physical powers of Nature counted for nothing in the game of human life. Yet a few simple instances will show at once the fallacy of such a view. If the ancestors of the Hellenic people had gone to the central plains of Russia instead of to the island-studded waters of the Ægean, could they ever have produced the magnificent Hellenic nationality with which we are familiar? Was not their navigation the direct result of their geographical position on the shores of an inland sea, intersected by jutting peninsulas, and bridged over by a constant succession of islands, each within full sight of its nearest neighbors? Was not their polity predetermined in large measure by the shape of their little mountain valleys, each open to the seaward in front and closed by a natural barrier of hills in the rear? Could their plastic genius have risen to the height of the Olympian Zeus and the Athene of Phidias if they had possessed no material for sculpture more tractable than the hard granite

of Syene? While we allow that the Aryan blood of the Hellenes had much to do with the differences which mark them off from the Negroid Egyptians, can we doubt that Hellenic civilization would have been very different if the settlers of Attica had happened rather to occupy the valley of the Nile; and that the Egyptians would have become a race of enterprising sailors and foreign merchants if they had chanced to make their homes on the shores of the Cyclades and the Corinthian Gulf?

Or, again, let us look for a moment at Britain. Who can suppose that the destiny of our country has not been profoundly affected by the existence of great coal-fields beneath its surface? Even if we possessed no mineral wealth, it is probable that our geographical position would still have insured us a considerable commercial importance as the carriers of the civilized world. Britain happens to occupy the central point in the hemisphere of greatest land, and this fact, aided by its insular nature, could not fail to make it a great mercantile country as soon as navigation, nursed in the Mediterranean, had advanced sufficiently to embrace the whole ocean-coasts of Asia, Africa, and America. But without coal and iron we should have been mere merchants, not manufacturers. London, Liverpool, Glasgow, and Southampton might possibly have been not inconsiderable marts for exchanging the products of other countries, and for balancing the trade in raw cotton or sugar from India and America against the textile fabrics and the hardware of France and Belgium. But we should have had no Birmingham, no Manchester, no Sheffield, no Leeds, no Bradford, no Paisley, no Belfast. Our population would not have reached one half its present size. Lancashire, the West Riding of Yorkshire, and the busy mining district of South Wales would be as thinly inhabited as Merionethshire and Connemara. The Black Country would be a quiet pastoral and agricultural region like the remainder of Warwick and Stafford. We should have no great towns except on the seaboard and the navigable rivers, and even these would only attain a fraction of their existing dimensions. Most of our people would be engaged in farming, and there would be no great wealthy class to crowd into Brighton, Scarborough, Cheltenham, Torquay, and the Scottish Highlands.

But this is not all: the difference in our national character would no doubt be very great. Coal has stimulated our inventive faculties and our enterprise, and has given an indirect impetus to science and art. Without it we should have had fewer mechanical improvements, fewer scientific discoveries, fewer railways, fewer colleges and schools. All these things have reacted upon our general level of intelligence and taste, and have enabled us to hold our own among the most advanced European nations. But without coal and iron we should have fallen back to somewhat the same position as that now held by Holland or Scandinavia, allowance being made for a larger territory in the first

case, and a thicker population in the second. Our comparatively insignificant numbers would reduce us from the rank of a first-class European power to that of a nation existing on sufferance. Our army and navy would be smaller; our Parliament less important and less stimulating to high ambitions; our churches, our bar, our medical faculty less advanced in the fore-front of thought. Thus we should probably suffer in every respect, producing both absolutely and relatively fewer great men, either as thinkers, administrators, discoverers, inventors, or artists. For, when once a nation has fallen behind in the race, the audience addressed becomes smaller, the competition less keen as an incentive to effort, the rewards of success decrease in value, and the general atmosphere of example and rivalry deteriorates in power. Where few books are written, few investigations undertaken, few works of art produced, few and still fewer care to aspire toward a forgotten ideal. Thus, without coal, Britain might have declined from the England of Shakespeare, Milton, and Newton, just as other countries have declined from the Hellas of Pericles and Plato, and the Spain of Cervantes and Velasquez.

The relation between physical conditions and history in its wider acceptation being thus fundamental, it may be well to consider in somewhat greater detail the special reactions of a single tolerably definite portion of the natural environment upon human development. For this purpose we may choose the science of geology. It might seem at first sight that geological facts had very little to do with the course of history. Rocks and clays, lying often far beneath the surface, and comparatively disregarded till a late stage of civilization, would appear far less important in the evolution of mankind than plants and animals, geographical situation and meteorological conditions. But, though doubtless of inferior practical interest to these superficial phenomena, the geological constitution of the soil is yet pregnant with innumerable reactions upon the life of human beings who dwell upon its surface. I hope to show in the sequel that the rocks or minerals which lie beneath the thin coating of earth and vegetation have always exerted an immense though often unsuspected influence upon the history of man. And I shall choose most of my examples from well-known facts of the British Isles, only diverging elsewhere very occasionally for the sake of more striking or more conclusive instances.

To begin with, it must be premised that geological conditions were of comparatively less importance in very primitive times, and have increased in their practical relation to humanity with every additional step in general culture. This is only what we must expect from the nature of the case. Man's connection with his environment has necessarily grown more and more complex as his evolution proceeded. Soil becomes a matter of interest sooner than building-stone; potter's clay precedes copper or iron ore as a valuable object; metals of every

kind are earlier required than coal. The mere savage needs nothing more from the mineral world than flint for his arrow-head and ochre for his personal adornment. A little later he requires bronze for his hatchet, gold and amber for his rude jewelry, clay for his hand-molded earthenware. A still more advanced race will learn to prize silver for coins, lapis lazuli for gems, brick-earth for Assyrian temples, granite for Egyptian colossi, marble for Hellenic sculpture, and iron for Roman swords. Only at a very late period of development will man begin to be largely affected by the neighborhood of zinc, lead, and mercury, of rock-salt, kaolin, and plumbago, of slate-quarries, marl-pits, and pipe-clay beds. Last of all will come the economic employment of coal, which in our own island has caused the aggregation of densely massed populations around the great centers of Glasgow, Manchester, Leeds, Sheffield, Newcastle, and Birmingham.

How general is the relation in early stages of civilization we can see from the comparatively close similarity between the life and arts of all the lowest savages. How special it becomes in advanced societies we can see when we consider the cases of Bethesda growing up by the side of the Penrhyn slate-quarries; of Broseley, entirely engaged in the manufacture of clay tobacco-pipes; and of Northwich, Middlewich, and Nantwich supporting themselves by mining rock-salt.

Nevertheless, even at the earliest period, geological conditions must have largely influenced human life. Tribes which lived among rugged granite or limestone mountains must have been very differently circumstanced from those which ranged over level tertiary lowlands, or settled on the alluvial deltas of modern rivers. During that primitive epoch which Sir John Lubbock has christened the Palæolithic age, when man first dwelt in Britain, we see traces of such primeval differentiation. The naked or skin-clad savages, who then hid among the caves of southeastern England, were ignorant of all the metals, as well as of pottery, and only employed rudely chipped weapons of unground flint. The neighboring forests then contained the mammoth and the woolly rhinoceros, the urus and the musk-ox, while the hippopotamus still basked on the banks of the Ouse and the Thames. But man appears at that period to have been wholly confined to the southeastern corner of England, from the coast of Devonshire to that of Lincoln. This district roughly coincides with that in which he could obtain flints for the manufacture of his weapons; and it also comprises the most level portion of Britain, where he might find comparative security and well-stocked hunting-grounds among the low-lying jungles of the eastern counties, the Thames Valley, and the tertiary plains of Hampshire. He does not seem at this early age to have ventured among the wild primary hills of Cornwall, Wales, the Pennine chain, and the Scottish Highlands, but rather to have clung about the river-fisheries and the flat shores of the southeast. Perhaps the bare and treeless chalk downs which run from Beer in Devonshire to the Norfolk

coast, backed by a forest-belt on the oölite in the rear, may have checked his westward advance through the fear of meeting the cave-lions and other savage wild beasts of the preglacial period on the open plain.

At a far later date, when man had progressed from the hunting to the pastoral stage, and had learned to fashion weapons of polished stone or bronze, which made him the acknowledged master of the brute creation, it is clear that a great change must have taken place as regards the relation to geological conditions. And in Britain the men of this later period certainly spread over the whole country, gathering most thickly, it would seem, where pasturage was easiest for their herds and flocks. This would naturally be upon those same undulating chalk downs which were doubtless objects of terror to the earlier race. Hence we find the tumuli and other memorials of the Euskarian and Keltic inhabitants—belonging either to the neolithic, the bronze, or the iron age—most thickly clustered around the great monument of Stonehenge on Salisbury Plain, among the downs about Brighton or Lewes, and on the sides or summits of the Yorkshire and Lincolnshire wolds. In those days and for many centuries after, the Weald of Kent lay as a wild forest-belt between the open chalk country to the north and south; while the primary hills and the river valleys still consisted for the most part of unbroken underbrush and woodland. Even in these early times, however, a commerce based upon geological differences had already sprung up: for the beautiful jade, employed as material for the finest hatchets, has been recognized as coming from the Kuen-Lun Mountains of Central Asia, while amber was already imported from the banks of the Baltic. Within Britain itself the Cornish tin-mines probably supplied the metal which mingled with copper to form the bronze implements of all Western Europe. An industrial population must even then have gathered with comparatively considerable density above the ores of the Land's End, while the valley of the Thames remained a mere desolate jungle wandered over by a few stray families of savage hunters.

Agriculture must first have developed itself over the whole world on low alluvial ground. Hence we find that all the great early civilizations occupy river valleys—such as those of the Nile, the Euphrates, the Ganges, the Indus, and the Hoang-Ho. Here alone can large masses of men obtain subsistence, before navigation and scientific agriculture have reached a considerable stage of evolution. Here, too, the density of the population and the level nature of the soil permit the growth of those vast despotisms under which alone an early society can be organized with any high degree of internal diversity. But just as navigation, nursed on inland and island-studded seas, spreads afterward to the wider oceans, so agriculture, nursed on well-watered alluvial plains, spreads afterward to drier, rockier, or more mountainous districts. In the desert uplands of the Punjaub, cultivation exists wherever wells can be sunk, even at immense depths, and

the industrious Jat peasantry work ceaselessly day and night by relays, each family raising the precious water to fertilize its own little plot, for a stated number of hours out of the twenty-four. But such industry presupposes a long training in more fertile soils, and a heavy pressure of population on all the earlier occupied alluvial lowlands. So too in Britain, a primitive agriculture would have despaired of raising corn upon the bare sides of the Chiltern Hills, and only modern scientific farming has turned the boggy upland expanses of the Cheviots and Lammermoor into flourishing tillage. Accordingly, we might expect that the growth of agriculture would bring geology and human development into still closer connection within our island.

Geologically, Britain falls into two well-marked divisions—the northwestern primary tract, and the southeastern secondary and tertiary region. The boundary between them may be roughly marked off by a line running from the mouth of the Tees to the mouth of the Exe. Northwestward of this line we have the whole of Scotland, the Pennine region of England, the Welsh mountain system, and the peninsula of Devonshire and Cornwall. Southeastward we have the whole level country of England, comprising the plain of York, the great central plateau, the Fen district and the eastern counties, the valley of the Thames, and the watershed of the south coast.

Now, it is not too much to say, that by far the most fundamental fact in the annals of Britain, since the dawn of written history, is the great revolution which has exactly reversed the relative importance of these two divisions. Yet what are called histories of England at the present day utterly ignore that revolution. In the Roman period and the middle ages, the most valuable and most populous part of Britain was the secondary and tertiary lowland: at the present day, the most valuable and most populous part is the primary division to the north and west. And what gives this revolution its greatest ethnological interest is the fact that while the secondary tract roughly corresponds with the Teutonic portion of Britain, the primary tract roughly corresponds with the Keltic or semi-Keltic portion.

As early as the time when Caius Cæsar, the Dictator, landed in our island, these two great divisions had already shown their differentiating characteristics. The Britons of the southeastern country, consisting of open and easily cultivable plains, had advanced to the agricultural stage, and were comparatively dense in their pressure upon soil, with fixed habitations and considerable towns. The northwestern tribes were still pastoral nomads or hunters, dwelling in movable villages, and having mere empty forts on the hill-tops, to which the whole population retreated in case of invasion. The difference thus expressed continued more or less marked throughout the whole historical period, until the use of coal effected that extraordinary revolution by which primary and industrial Britain has at length asserted its superiority to the level agricultural southeast.

Under the Romans Britain became a corn-producing and grain-exporting agricultural country, like the America of our own day. And just as the valley of the St. Lawrence and the northern Mississippi basin now form the most important wheat-growing part of America, so the valleys of the greater rivers formed the most important part of Roman Britain. The plain of York, formed by the Ouse and other tributaries of the Humber, is the largest low-lying corn-field and meadow-land in our country. It consists mainly of triassic strata, overlaid in the lower reaches by a deep bed of alluvium. In the center of this rich agricultural tract lay the Roman provincial capital of Eboracum. Another wealthy region is the post-tertiary level of the eastern counties; and here the colony of Camalodunum lay surrounded by numerous villas of rich land-owners. The tertiary valley of the Thames shows its importance by including the considerable cities of Londinium, Verulamium, and Rhutupiæ. Other Roman towns—Lincoln, Cirencester, Bath, and Dorchester—filled up the rich oölitic and green-sand belt of central England; while Winchester overlooked the tertiary vale of the Itchin at Southampton, and took its name of Venta Belgarum from the agricultural lowland at its doors. We may gather from the Roman historians that the occupation of southeastern Britain was real and thorough. The native population was reduced to serfdom, and the country became a mere feeder of Rome or of the Gallic cities.

Primary Britain, however, seems never to have fallen into so miserable a condition. The Roman supremacy was here probably confined to a mere military occupation, like our own occupation of Kumaon or the Simla Hills. Caledonia never fell into their hands, and even in Wales and the Pennine chain we find only military stations, like Isca Silurum or Segontium, not large cities like London, York, and Lincoln. Even where the Romans thoroughly penetrated the primary region, as in Cornwall or the Forest of Dean, it was always for a geological reason, to secure the mines of tin or iron. This difference, I believe, had almost as much to do as geographical position with the subsequent relations of the Britons to the English invaders. While the servile herd of the Belgian, Icenian, Trinobantian, and Brigantian country, demoralized by Roman centralization, fell easily before the Jutish or Anglian pirates, the more independent mountaineers of Wales, Cumbria, and Strathclyde long resisted the English onslaught, and only at last succumbed as free subject races, instead of being enslaved or exterminated like their eastern fellow countrymen. The Scottish Highlands not only retained their own independence, but even gave their kings to the Teutonic Lothians. Granite naturally makes freemen, as alluvium naturally makes slaves.

When the English settled in southeastern Britain, they occupied for the most part the secondary and tertiary plain. But they also pushed northward into the primary region up to the Firth of Forth, as

the Romans had done before them. The Teutonic invaders, in other words, took the best agricultural lands for themselves, while the Kelts were driven back into the rugged primary tract of hill and forest. Throughout the middle ages, agriculture and grazing formed the staple English industries. Accordingly, during the early English period, we find all the more important towns occupying the cultivable valleys or gentle plains. Canterbury and Rochester, the two Kentish capitals, stand in the midst of tertiary lowlands; London, the final royal city of the West Saxon kingdom, lies surrounded by a similar tract; the Oxfordshire Dorchester, first home of the Wessex kings, is on the border of the rich vales of Aylesbury and Oxford; Winchester, their later seat, commands the valleys of the Itchin and the Test. Norwich, Bury St. Edmunds, and Ipswich were important centers for the East Anglian drift. Peterborough and Ely rose among the levels of the Nen and the fens of the Ouse. Lincoln, Oxford, and Chippenham stood upon the great central oölitic belt. Cambridge occupied a low-lying corner of the cretaceous system. Exeter, Lichfield, and Chester were girt round with the fertile triassic meadow-lands. York still remained the capital of the north, and the metropolis of a kingdom which long retained the foremost position held by the north under Roman rule. These were the great cities of England before the Norman Conquest, and not one of them stands upon a primary formation. All of them, save only London, have now sunk to the position of mere cathedral cities, university towns, or agricultural centers. But Edinburgh, Glasgow, Manchester, Leeds, Sheffield, Newcastle, Bristol, and Cardiff, the great cities of to-day, are all built upon primary rocks; while the only two important modern towns which rest on later strata are Birmingham, on the borders of the Black Country coal-field, and Liverpool, which lives by conveying the cotton of America to the great Lancashire colliery district around Manchester, Rochdale, and Oldham.

In the later middle ages England became a wool-stapling country. Bales of wool were shipped from the Orwell for Flanders and Italy, as they are now shipped from Australia for Leeds and Bradford. This was the first step toward making Britain a commercial country. Before the Norman Conquest it had been an essentially agricultural and self-sufficing community, growing all that it required to meet its own simple needs, and neither exporting nor importing goods to any noticeable extent. But the wool export created a foreign trade. Ports sprang up along the south and east coasts, from Dartmouth, Topsham, and Lyme Regis to the now forgotten haven of Ravenspur-on-Humber, the precursor of our modern Hull. This trade gave importance to the chalk districts, high sheep-walks now the barest and least inhabited portion of southeastern England. Not a single town of any pretensions at present occurs in any part of the downs or wolds. But Dorchester, Shaftesbury, Old and New Sarum, Winches-

ter, Lewes, Reading, Wallingford, Cambridge, and Beverley, were all places of great mediæval importance, and all stand within the cretaceous area. Other wool-growing tracts of course possessed a similar value.

A few more special agricultural features of the various secondary or tertiary geological formations may here be fitly introduced. The Trias and other "Poikilitic" strata, running across England from the Tyne to the Exe, form beautiful undulating country, comprising much of the best wheat-growing and pasture land, and famous for the production of cheese. In this belt lie the vale of York, the Trent and Severn Valleys, the Cheshire Plain, and the vales of Exeter and Taunton. An outlier forms the valley of the Eden at Carlisle. The Lias, which follows the Poikilitic series to the southeast, is a good soil for corn and apples, but also produces the most excellent cheese in England, as Mr. Woodward has pointed out. Along the Severn bank it furnishes the double Gloucester; at Melton Mowbray and Leicester it produces Stilton; and in Somersetshire it unites with the triassic red marl to yield the Cheddar. The fruitful vales of Eversham and Gloucester belong to this formation. The Oölite gives us the rock known as cornbrash, which disintegrates into a splendid wheat-bearing soil, naturally manured by its large quantities of phosphate of lime, the so-called bone-earth. The Oxford Clay, on the other hand, is poor and hard to cultivate, so that most of it lies under permanent pasture. It forms the sheep-feeding vale of Blackmore, in Dorset. The Kimmeridge Clay, in like manner, does not repay cultivation, and is mostly employed for meadow or woodland. The Wealden, forming the great trough between the North and South Downs, is another of the infertile soils. It remained a great wood, the Andredesweald, or Forest of Anderida, for a long period after the English conquest, and the local names of the district still retain their forestine terminations of *hurst*, *ley*, *den*, or *field*. Even at the present day the Weald is damp and clayey land, little tilled, and either laid down in pasture or given over to furze and heath. The Gault makes good grazing-lands, and the Upper Greensand is in every respect a fertile formation. These two series yield the rich Vale of White Horse, through which the Great Western Railway runs between Swindon and Didcot, as well as the vale of Aylesbury, whose name has become synonymous with pure milk. The Chalk supplies us with South Down mutton, said to owe its excellence not so much to the pasture itself as to a small land-snail (*Helix virgata*) which the sheep devour in great numbers.* The London clay, though stiff, can be made to yield good crops. Drift forms

* These little mollusks themselves abound upon chalky soils, and are found nowhere else, because they require large quantities of calcareous matter to form their banded shells, while other species with more horny coverings live on soils where less lime can be obtained. No snails can inhabit the limeless district of the Lizard in Cornwall. So minute are the interpendences between every portion of organic and inorganic nature.

the great East Anglian plain, while the Fen country, the Somersetshire levels, and Holderness consist mainly of alluvium. Thus we see that, little as the mediæval farmer suspected it, the distribution of his corn-fields and pasture-lands, his orchards and sheep-walks, nay, even of the royal forests and the barren heaths, was finally dependent upon underlying geological conditions.

Even in mediæval and agricultural England, however, certain particular spots acquired a special industrial character from the nature of the subjacent strata. The occurrence of fuller's earth in the Stroud Valley and near Bath and Bradford gave rise to the west country cloth-trade. Salt was pumped from several inland wells in the Trias at Droitwich in Worcestershire, at Northwich, Sandbach, Middlewich, and Nantwich in Cheshire, and at Shirleywich in Staffordshire. The bays in which sea-water had been evaporated to yield salt had been known as "wyches," and the same word was applied to the new wych-houses of the interior. Clay suitable for potteries was found in many places, and naturally produced a small trade. But mines were little worked, and building-stone, of which more must be said hereafter, formed almost the only other geological differentiating factor between various districts.

The change to the modern industrial distribution is far too large a subject to be treated otherwise than quite cursorily here; but a few traits of the change may perhaps be sketched with a rapid pen. In Britain mineral wealth is almost universally connected with the primary formations. Our coal more especially has formed the great central pivot upon which turns the whole manufacturing and commercial system of the country. As soon, therefore, as the use of steam began to revolutionize our industrial world, the primary tracts of England, Wales, and Scotland, rose to the highest importance. The population of Britain suddenly found itself turned back upon the Keltic and coal-bearing regions. A slight classification of the various great towns of modern Britain according to the coal-fields in which they stand, or on which they depend, will serve to show the vastness of the revolution.

In or around the Scottish coal-field stand Glasgow, Paisley, and Greenock. Above the Tyne colliery region are Newcastle, North Shields, and Durham, while close at hand lie Sunderland, Stockton, Darlington, Middlesborough, and the Cleveland iron district. The Lancashire field incloses Manchester, Blackburn, Wigan, Bolton, St. Helens, Burnley, Middleton, Oldham, Rochdale, and Ashton, with Liverpool for its port, and Preston and Macclesfield upon its outskirts. An outlier contains Stoke-upon-Trent and Newcastle-under-Lyne. The West Riding coal-field includes Leeds, Bradford, Wakefield, Barnsley, Sheffield, and Chesterfield, while Huddersfield, Nottingham, and Derby hang upon its border, and Hull supplies it with an eastward outlet. The Staffordshire tract comprises Wolverhampton, Bilston,

Dudley, Wednesbury, and Walsall, with Birmingham for its real center.. Other carboniferous deposits occur in Coalbrookdale, in the crowded South Wales district, and near Bristol. If all these are put together, it will be seen that they compose almost all the great foci of British life and manufactures at the present day.

On the other hand, what are the great towns in the secondary and tertiary southeastern tract? London, the main distributing center, preserved by its navigable river, and its official importance. Southampton, a convenient Indian and South American port. Plymouth and Portsmouth, two government naval stations. Chatham, an artificial creation for purposes of war. Scarborough, Brighton, Cheltenham, Bath, and half a dozen other lounges for the moneyed classes. All these ultimately depend for existence upon the wealth created elsewhere. Leicester is almost the only town in purely Teutonic England which now earns a good livelihood by industries unconnected with the sea or with warlike preparations. Turning to the north, Edinburgh survives by its traditional position as a metropolis and as the center of the Scottish Church, the Scottish law, and to some extent the Scottish aristocracy, as well as by its possession of a university and a great cultivated society. But Edinburgh itself stands on a primary site.

The specialties of the modern system are far too numerous to allow even of passing exemplification. Here coal, there iron, in other places lead or tin, forms the source of wealth and the determining cause of human aggregation. The potteries draw men to Staffordshire; finer clays produce the ware of Worcester, Lambeth, or Dunmore. Flags for paving are largely worked in North Wales. Lime from blue lias keeps alive more than one small seacoast town. Even gold is mined near Dolgelley in Merionethshire. Phosphate of lime is collected as mineral manure. Cutler's green-stone and beds of jasper are found among the Cambrian rocks. Millstones, hearthstones, and fire-clay are other useful economic products. Terra-cotta is made at Watcombe, near Torquay. Epsom salts are manufactured from magnesian limestone on the Tyne. Slates for roofing, plumbago, Cairngorm pebbles, afford occupation in other parts to quarrymen and lapidaries. Glass can only be made where flints are obtainable. Whitby derives a small fortune from alum, jet, and the sale of fossils. Guernsey lives largely by exporting its granite as road metal to London. Whetstones supply an industry to Whittle Hill, and slate-pencils to Shap in Cumberland. But perhaps the strangest trade of all is that of the gun-flints, still manufactured at Brandon and Norwich to supply the savages of Africa, whither all the old flint-locks of Europe were shipped on the invention of percussion caps.* The water-supply everywhere depends upon geological conditions. Even our pleasure resorts and

* I owe this, with many other facts, to Mr. H. B. Woodward's interesting "Geology of England and Wales."

watering-places owe their attractions to similar considerations, as we can see when we examine the igneous masses of the Scotch Highlands, which form the chief heights of the Grampians; or when we remember that the self-same Cambrian rocks recur in the loveliest part of North Wales and in the Westmoreland lake district. So too in Devonshire, the regular tourist tract from Ilfracombe to Lynton and Lynmouth lies through the wild Devonian strata, which, interspersed with granite, once more reappear on the other tourist coast-line from Torquay to Land's End. Those who admire Ramsgate and Margate, with their bare, treeless downs and white chalk-cliffs, may also content themselves with the similar scenery of Dover, Folkstone, Eastbourne, or Brighton; but a different type of mind will prefer the wooded vales of Hastings, where the Weald comes down with its pleasant broken country to the seashore.

One last word may be given to the influence of geology upon art. We can hardly deny that the whole æsthetic development of Egypt must have been largely affected by its alternation between solid granite and the mud of the Nile. So, too, the Parthenon and the Apollo must have owed much to the marble of Paros and Pentelicus. China has doubtless been greatly influenced by the presence of kaolin clay. In Assyria, brick necessarily formed the chief building material; and in Upper India the monasteries and stupas of the Buddhist Emperor Asoka are still recognized by their huge, sun-dried bricks. Chryselephantine art could never alone produce high results; marble and alabaster would naturally yield far more elevated works. In Britain we may look for similar effects of the geological environment.

As early as the age when Stonehenge was piled up, building-stone was selected for special purposes, since the outer circle of that prehistoric monument consists of the Sarcen bowlders of the neighboring plain; but the inner pillars are of diabase, and have been brought from some unknown distance. During the middle ages Caen stone was frequently imported for building churches or other important architectural works. Before the Norman Conquest, however, most English buildings were of wood, so that, "to timber a minster," not to build a church, is the good early English expression of the chronicle. In chalk districts, at a later date, broken flints were often employed, and they give a mean appearance to the abbey ruins and churches at Reading, as well as to most of the older edifices at Brighton. Oxford, however, on the Oölite, is happily built of good native or imported stone. In modern times, London, standing in the midst of the brick-earth, has fallen a victim to the miseries of stucco,* until the Queen Anne revivalists have endeavored to restore an honest red brick; whereas Edinburgh, surrounded by excellent building-stone, has been able to do justice to its magnificent natural situation, and

* Parker's cement, manufactured from the septaria of the London clay, is answerable for the outer coating of our West-end houses.

Aberdeen has clad itself in the stern but not unattractive gray and blue of its own solid granite. To the Caen stone, the Bath stone, and the Portland stone we owe half our cathedrals and abbeys, whose delicate tracery could never have been wrought in Rowley rag or Whin Sill basalt. The architecture of granite or hard limestone regions is often massive and imposing, but it always lacks the beauty of detailed sculpture or intricate handicraft. The marble lattice-work of the Táj or the "prentice's pillar" of Roslyn Chapel is only possible in a soft and pliable material.

Thus we see that agriculture and manufactures, art and science, are all largely influenced by geological conditions. Indeed, it would not be too much to assert that, after climate and geographical situation, geology is the greatest differentiating agent of national character. Every people is primarily what it is in virtue of the heredity it derives from the common ancestors of its whole stock; but, so far as it differs from other descendants of the same stock, the differences must mainly have been caused by those three great natural agencies, acting and reacting in conjunction with the original hereditary tendencies. The immense complexity of such actions and reactions renders them difficult to trace in detail; but the general principle which they illustrate can hardly be missed by those who read history with a wide and comprehensive glance.—*Fraser's Magazine.*

THE CINCHONA-FORESTS OF SOUTH AMERICA.

By HENRY S. WELLCOME.

IN the month of June, 1879, I visited some of the principal cinchona districts of South America. The following notes are based upon my own observation and information obtained from native bark dealers and gatherers. I shall speak more particularly of the cinchona-forests of Ecuador, once the only source of bark, and still yielding large quantities. The bark territory is divided into the district known as Bosque de (forest of) Guaranda and Bosque de Loja.

The Bosque de Guaranda is a vast forest, extending from about 1° north to 2° south; it covers with its rich verdure the western slopes of Chimborazo, and the outlying ranges of the Cordilleras to more than ten thousand feet above the sea-level, encompassing within its higher limits the picturesque city of Guaranda. This district is the source of most of the barks exported from Guayaquil, and has never yet been fully explored. Guayaquil, the main shipping port of Ecuador, is a city of thirty thousand inhabitants, situated on the Guayaquil River, sixty miles from its mouth. The river is navigable to this point by large ocean-steamers. The southern extremity of the Bosque de Guaranda

is reached at Pueblo Nuevo, a small town on one of the eastern branches of the Guayaquil River, about seventy-five miles from this town. A small steam-launch plies between the places.

The elder cinchona district, Bosque de Loja, was the source of the first barks taken to Europe. It extends from 2° to 5° south, to the boundary-line of Peru, and covers the western slope of the Cordilleras below the timber-line. This district has been worked constantly for over two hundred years, and the quantity of bark it furnishes to the Guayaquil market has fallen off in recent years.

At Pueblo Nuevo, mules and servants were engaged for the journey to the mountains. Wheeled vehicles are useless, for want of roads, and all transportation is done on the backs of beasts or Indians. Before reaching the highlands, forests of ivory-nut palms with their long, graceful, feather-like branches, and scattered trees of *Cinchona magnifolia*, a valueless species, are met with. Occasionally we found clearings, with extensive *haciendas* of cacao, coffee, sugar-cane, and anatto. The farther we got into the higher mountains, the more the difficulties and dangers increased, and at last a point was reached where the mules had to be abandoned, and, after continually ascending and descending steep places, a point on one of the great spurs was reached, whence was seen an undulating sea of wilderness as far as the eye could reach—a gorgeous expanse of matted verdure; here and there tall, slender columns of gigantic palms pierced the forest-roof, and gracefully waved aloft their drooping branches and leaves; and now and then a huge bank of clouds drifted up, like a Newfoundland fog, curtaining the grand scene for a few moments, and then quickly passing off. Our *cascarillero* soon descried some cinchonas in the distance by their glistening leaves, which reflected brightly the vertical rays of the sun.

This characteristic reflex of the foliage, with the bright, roseate tints of the flowers, and in some species also of the leaves, affords the means of discovering the cinchonas among the mass of the forest giants. The glossy leaf of the India-rubber tree is easily mistaken for the cinchona, but skilled cascarilleros are usually able to distinguish, at a great distance, varieties by the color of the flowers and general appearance of the tree.

At the bottom of a ravine we followed a small stream, till suddenly our guide shouted, "Cascarilla!" and we were gladdened by the sight of a number of fair-sized trees of *Cinchona succirubra*.

The cinchonas seek the most secluded and inaccessible depths of the forests; they are rarely grouped in large numbers or close together, but are distributed in more or less irregular, scattering patches. The older trees are grand and handsome, forty to eighty feet in height, trunks straight, branches regular, leaves evergreen (six to ten inches long), of a dark-green color, sometimes tinged with crimson, the upper surface of an almost waxy luster, flowers in terminal panicles of

bright rose-tint and of an agreeable fragrance. The bark of the large trees is usually completely covered with mosses of the most delicate, lace-like texture, interspersed with lustrous, variegated lichens and diminutive, trailing ferns, while air-plants and vines in profusion entwine themselves among the branches of the trees, and hang in graceful festoons, forming hammocks, in which clusters an abundance of parasitic growth, particularly of the orchid family. Vegetable growths develop with wonderful luxuriance beneath the interlacing branches, which permit but little access of sunlight underneath. Everything is saturated and dripping with moisture; the very air we breathed seemed a clammy, aromatic vapor. In these vast forests atmospheric changes are continuous and abrupt; drifting banks of gloomy clouds are followed by glaring sunshine, and then tempestuous showers—all in rapid succession. The temperature is more even, averaging about 65° Fahr., seldom exceeding 80° or falling below 45°, the altitude being about six thousand feet.

To discover cinchona-tree patches in the forests, the cascarilleros ascend such high spurs as command a good view of the surrounding valleys and mountain-slopes. After discovering a forest that indicates sufficient value to render it profitable to work, a certain limit of forest-land is condemned and a claim made to the Government; upon the payment of a certain fee, a title is granted on very much the same plan as those upon mining claims in the United States. The next step of the cascarillero is to apply to a bark-dealer for funds with which to work the claim: if he can present satisfactory evidence that his forest is a profitable one, sufficient money is usually advanced, the merchant holding the title as security, with an agreement that the bark shall be delivered and sold to him exclusively; sometimes the dealers purchase claims outright, and employ men to work them. For many years the bark-trade of Bolivia was monopolized by the Government; the cascarilleros were obliged to sell their bark to a bank established for the purpose, and receive for it whatever price the officials chose to pay. This system was conducted with such flagrant injustice and dishonesty that it was finally broken up. Now, each republic levies a duty on all barks exported.

The season for bark-gathering begins about the 1st of August (in some forests as early as June), and lasts till October or November; during these months the bark cleaves most readily, and, on account of less rainfall, the forest is more accessible. It is next to impossible to enter it during the wet season. A master cascarillero with his gang (sometimes several hundred peons) establishes a main camp in the forest, on an elevated point where there is an opening in the forest, so as to allow the bark as much exposure as possible. The peons are formed into squads, and scatter through the forest, establishing small camps. When they are ready for work, and the bark-gathering begins, one or two from each division seek out the trees, while others

cut down and peel them. The trees are first decorticated from the ground up as far as can be reached, and then, after felling and removing the clinging vines and mosses, the rough, outer bark is beaten off with a club or mallet. The bark is then cut around the trunk in sections of two to three feet, and longitudinally in strips of six to eight inches in width, then removed with the blade of a *machete*.

When first taken from the tree the inner surface of cinchona-bark shows a handsome cream-tint, but, on exposure to the atmosphere, rapidly darkens to a dirty red. The barks are usually taken to the main camp for drying and storage. The thick bark of the trunk requires great care in drying, because of the excessive dampness of the atmosphere, which sometimes necessitates the use of artificial heat to prevent molding; it is piled up in tiers with sticks between the layers to allow free circulation of air, and heavy stones or fragments of rocks are placed on top to flatten it. The thin bark from the young trees and small limbs dries more rapidly, and rolls itself up into quills.

One of the greatest difficulties connected so far with the gathering of cinchona-bark is that of transporting it to the coast at the end of the season. It is roughly sorted, mainly according to the part of the tree from which it is obtained, and packed in bales of about one hundred and fifty pounds each; the Indians carry these bales on their backs a distance of sometimes hundreds of miles to a transfer warehouse, whence it can be transported by mules to the nearest shipping-place. The worn appearance of most flat bark of commerce is due to the long friction which it undergoes during transportation.

The Indians, in carrying bark, bear the main weight of the burden upon their heads, by placing over the forehead a strip of rawhide to which are attached cords of the same material lashed to the bale; they stoop forward to maintain their equilibrium, and use long Alpine sticks to steady and aid them in ascending or descending dangerous cliffs. The skeletons of hundreds of wretched peons can be seen in the far depths of the chasms below of some of the older trails, bleaching beneath the tropical sun, whose earthly toils were ended by a misstep on the verge of one or the other frightful precipice, and now and then ghastly human skulls are seen placed in niches or crevices in the projecting rocks of the mountain-sides along the narrow passage, suggestive of lurking dangers. Another fearful terror to the Indians is the malarial fevers, to which they quickly yield, owing to great exposure and want of nutritious food. It was said that, during a recent severe malarial season, as many as twenty-five per cent. of the Indians employed in one district died from fevers before the harvest was completed, and it is only by extreme poverty, or obligations as peons, that they are induced to enter the bark forests to encounter the dangers for the meager pittance of ten to twenty-five cents per day.

The final sorting and classifying of bark are done at the main store-

houses at the coast, where it is closely packed in ceroons of previously moistened cowhides (hair-side out), or in bales of heavy sacking. There it is that most of the adulteration is done. The admixture of inferior barks with higher grades is not so much the result of ignorance as sometimes supposed, for the bark-dealers are generally very expert in determining the different varieties and estimating the values of barks. Yet, strange to say, very few bark-merchants ever become wealthy.

All barks enter the market bearing certain brands; these brands used to gain a reputation according to the quality of bark they represent, but frequent occurrence of sophistication of reputed brands with inferior grades of bark has brought on the result that large buyers do not any more purchase cinchona-barks without first making careful assays, but even with this precaution they are sometimes deceived, on account of the adroit manner in which the barks are mixed.

The points of shipment for Ecuadorian barks are Guayaquil and Esmeraldes; for the barks of northern Peru, Payta; from southern Peru and Bolivia, Arica, Islay, Iquiqui, and Callao. A limited quantity of Bolivian bark is exported by way of the Amazon to Para. The greater portion of the bark produced in the northern and eastern districts of the United States of Colombia reaches the market by way of Carthagena and Baranquilla on the Caribbean coast, but that collected in the state of New Granada is mostly shipped from Buenaventura on the Pacific coast. Venezuela furnishes very little bark, and that is sent from Puerto Cabello.

As regards the prospects for future supplies of cinchona-barks from the native forests of South America, the outlook is exceedingly discouraging; the greatly increased use of cinchona alkaloids during the last few years, with the consequent demand for larger supplies of bark, has caused a very thorough working of the old forests, and energetic seeking for new ones. The discoveries of paying forests are becoming more and more rare every year, and the new forests are found at greater distances from the shipping ports, and are more difficult of access.

The tract of country yielding the cinchona is not so unlimited as some writers would lead us to believe, nor is the supply inexhaustible; it is a fact recognized by natives and dealers, who are well informed about the extent and resources of the cinchona-bearing districts, that if the present ruinous system of destroying the trees is continued, and no effort made to propagate new growths, they will, before many years, be practically exterminated from their native soil.

With the abundance of seeds yielded by the cinchonas, one would naturally expect young plants to spring up in great numbers, but such is not the case; the light-winged seeds mostly fall upon and adhere to the ever-moist foliage, where they quickly germinate and decay; or, if, perchance, they fall to the ground, it is exceedingly difficult to gain

a rooting, as the soil is covered to a depth of ten to twenty inches with loose, decaying leaves. Beyond all doubt, the cinchonas might be successfully cultivated in their native country, especially in the exhausted forests; but the natives show no enterprise, and foreigners receive no encouragement from the governments to attempt it. Two Germans have recently made a venture at cultivating cinchonas near the city of La Paz, Bolivia, but as yet the plants are not sufficiently developed to determine the results.

The almost continuous revolutions and wars in those South American countries so unsettle everything as to render investments hazardous; the roads and ports are sometimes blockaded for months, preventing the importation of goods or shipment of barks, often entailing heavy losses upon the dealers.

In case of war or revolution, every Indian peon is subject to military duty, and, if required, is forced to enter the army; sometimes it is impossible to obtain sufficient cascarilleros to make it pay to enter the forests; hence it is that political troubles in those countries so greatly influence the price of bark and quinine.

The efforts of the Dutch and British Governments in taking energetic and extensive measures, by establishing vast plantations of cinchona-trees in their eastern colonies, to insure against the possibility of the world's bark-supply becoming exhausted, are therefore of paramount importance; and it is a matter of general concern and gratification that their experiments are proving from year to year more successful, yielding an excellent, ever-increasing supply of bark, mostly rich in valuable cinchona alkaloids.

TYPES OF THE NUBIAN RACE.

PROFESSOR A. KIRCHHOFF has published, in the "Transactions of the Geographical Society of Halle," an interesting description of a party of Nubians who came to that city with the caravan of Messrs. Rice and Hagenbeck. The traveler Marno, in his "Journey into the Egyptian Equatorial Provinces and in Kordofan," gives a flattering account of the handsome forms and features of the youth of the nomadic people of those provinces, with the faces of the boys so fine and soft that one might be made to doubt whether they may not be girls. These handsome traits disappear as the youth grow older, and give way to repulsive ones, especially among the women. One of the most striking peculiarities among the men of the Bishareen and Hadendoah is their manner of wearing the hair. After being worked up into a great tuft on top of the head, it is smeared as thickly as possible with tallow, which, melting under the warmth of

the sun, flows down over the face and the back of the neck, and anoints them well. This account, although it relates especially to the pastoral races, whose range extends from the northern boundary of Abyssinia and the Nile to the Red Sea, is equally applicable to the tribes of southeastern Nubia. The twelve individuals attached to the Rice-Hagenbeck caravan, from the tribe of Beni Amr, in the southeast, afford a pleasant exemplification of the characteristics noticed by Marno. The illustrations are faithful portraits of members

ADAM NOD EDRIS. HAMID NOD MOHAMMED.

(From Photographs.)

of the party, and give truthful representations of their forms, attitudes, and expressions. They convey no suggestion that these Nubians belong to the negro race, but show, instead, noble features, without flattening of the nose or exaggerated prominence of the jaws. The gentle prognathism and full lips of the figures remind us of the ancient Egyptain profile, the nose of the Semitic type. Their dark-brown skin does not disturb the pleasant impression which their fig-

ures make, but gives to their well-built, slender, elastic forms, with their graceful bearing, an appearance like that of bronze statues, especially when they are lighted up by the sun. The eyes of the Nubians at Halle were, without exception, dark brown, with a beaming glance, the whites mottled with yellow or brown. They all wore their lusterless black hair after the fashion common everywhere in the Bêdsha, with the top hair done up over the head in the form of a pillow, the rest of the hair twisted into loose tufts hanging downward over the ears, and gathered at the bottom into broad curls. They all had a growth of beard, not very thick in any of them, but much stronger than it is generally supposed that they have, and much like that of the south Arabians. Little or no hair grew on other parts of the body, except that they had some strong black hairs below the knees. Their height varied from five feet three and three quarter inches to five feet ten and three quarter inches, the girth of their calves from eleven and one half inches to fourteen and one quarter inches, giving an average height of five feet six inches, and an average measurement of nearly twelve and three quarter inches around the calf. The form of their skulls fixed their place among the mesocephalic races, and, with the broad facial index of seventy degrees and a small per cent., gave to the face the shape of a "well-formed oval of moderate breadth." The head rested on a moderately short, strong neck, and the muscular development of the neck, breast, and arms was very fine. Except in the palms of their hands and the soles of their feet, they appeared to be deeply colored, especially in the covered parts of the body; but the brown in the face was a little more inclined to a bronze color. The membranous skin in the corners of the eyes and on the lips participated in this coloration, and this made the splendidly preserved teeth appear all of a brighter white. The ring-finger in all extended beyond the forefinger, and the great-toe was shorter than the second toe. Their mother-tongue was the ancient Bedanîe, the Bêdsha language, but they also spoke Arabic. Their senses of hearing, smell, and sight were delicate and sharp. No trace of color-blindness could be found among them. They distinguished with ease fifteen colors, several of which were very nearly related, but had no particular terms for yellow, or to distinguish between blue and green. This fact contradicts the theory that the absence of a particular name for a color indicates a destitution of the faculty of recognizing it among other colors. For colors for which they had no specific name they used the word *sotâi*—colored.

In a like manner, says Kirchhoff, the Djâlin in adopting the Arabic language use the Arabic word *achder* (green) also for blue, and the written Arabic *assek*, blue, more in the sense of black and brown. This may throw some light on the meaning of *Bahr-el-Assek*, which we translate Blue Nile, after the meaning of the written Arabic word, when it might be better to follow the local meaning, and call it dark

Nile, in distinction from the *Abiad*, or clear Nile. Kirchhoff believes that the race-kindred of these people are to be found among the dark-brown tribes of eastern Egypt and Abyssinia, and the Hamitic branch of the Caucasian race, and maintains that they ought to be considered as a people of some cultivation. They all squatted on their heels when they sat down. It was interesting to notice how, when they sewed, they threw the cloth over the left knee, and held it fast between the first and second toes of their right foot. They spent the day in a round of sleeping, smoking, talking, and strumming upon their five-stringed (otherwise very primitive) guitars, alternating these idle occupations with the important daily business of dressing their

MOHAMMED NOD ALI (Profile and Front View). (From Photographs.)

hair. They did not put fresh tallow upon their stately head-dress every day, but they performed punctually for each other the mutual service of arranging the cushion, using the wooden pin a foot long, with which it was fastened, as the instrument. The looking-glass was used industriously, for the inner eyelids could not be painted without it. They cleansed their teeth regularly with a short light stick of the arâk-plant, which they had brought with them from home for the purpose. Beyond this they washed themselves but little. Each one carried his "Allah" on his upper arm, a small casket inclosing a text from the Koran as an amulet. Their feet were protected with sandals, while their heads were uncovered, and they wore a small silver ring in the lobe of their right ears, and a chain of colored pearls on their necks. A belt containing the dagger was worn over their white dress, which they knew how to draw around them with considerable artistic grace.

ALGEBRAS, SPACES, LOGICS.

AN UNTECHNICAL ILLUSTRATION OF DEVELOPMENT IN PURE SCIENCE.

By GEORGE BRUCE HALSTED, A.M., Ph.D.

WHEN at the making of a new university a lot of specialists were thrown together, I was impressed by their lack of information in regard to the progress of the eldest of the family of sciences, mathematics. One fellow, a graduate of the University of Virginia, said that, from what had been taught him, he had come to believe mathematics finished by Newton, and now he was puzzled by a talk of progress. Another, an engineer thoroughly grounded in what the previous one had considered all possible mathematic, asked what it could mean—this turning out of new algebras, this new geometrizing? He had heard that metaphysics was interminable, and knew that a pseudo-philosopher could spin out metaphysic by the yard; was this new mathematic something of the same sort, or was it worth his looking into?—and so on. Let me, then, try to give an untechnical illustration of the fact that mathematic, though with a safe start of perhaps a thousand years over the other sciences, may now lay claim to be more than ever fundamentally and rapidly advancing, developing. From the vast field of choice, let us, to fix the attention, confine ourselves simply to what is involved in the addition of a single letter, *s*, to three common words, algebra, space, logic; that is, implied in getting a plural to the ideas embodied in these words.

Algebra has been and still is defined as universal arithmetic, and is most commonly thought of as simply a generalized statement of the truths about natural numbers. And historically such it was; as such it started, and was indeed a very gradual growth. In the first known treatise on the subject by Diophantus, in the third or fourth century, the few symbols employed are mere abbreviations for ordinary words. The Arabians, who obtained their algebra from the Hindoos, did little or nothing toward its extension, though it retains in its name an Arabic touch, and the word *algorithm*, always, and now more than ever, associated with it, has the Arabic *al*. It was after their treatises had been carried into Italy by a merchant of Pisa, about 1200, that important improvements began. About 1500 the first problem of the third degree is said to have been solved. After that, Cardan first gave the general solution of a cubic equation, and employed letters to denote the unknown quantities, the given ones being still mere numbers. Toward the middle of the sixteenth century algebra was introduced into Germany, France, and England, by Stifel, Peletarius, and Robert Recorde, respectively. Recorde endowed it with the symbol of relation =, and Stifel with the far more important symbols of operation,

$+$, $-$, $\surd$. In the same century Vieta introduced letters as symbols for known as well as for unknown quantities, and by this great advance not only laid the foundation for the general theory of equations, but rendered possible the birth of new algebras, children of the first.

The next step, a vast one, was definitely accomplished, when, in 1637, Descartes published his "Coördinate Geometry," involving an algebra of form. Sprouting from a numerical stem, this soon transcends merely metrical limits with a beautiful power of giving demonstrations projective, positional, descriptive. It matters not whether you prefer to think of this as a new algebra or as a new application of the first algebra of natural number. But, if you take the second opinion, you should know that you do so because the child is almost identical with the parent in formal algorithm. And there is a word coming into general use in pure science, yet whose present meaning is scarcely to be gained from dictionaries. It is an interesting word both in its birth and growth. When the Greek learning passed to the Arabs, so did the word ἀριθμός, as it has come to us in arithmetic. When the Arab and Moorish learning passed into Europe, the *al* was confounded with the following word, and from the Spaniards came the *g* between them. Thus, when the Indian numerals were introduced, this word came with them, and the new figures were denominated (by Chaucer, for example) *augrime* (or algorithm) figures; and rightly enough as being used according to an algorithm, for the old mathematical dictionaries give it in probably its real imported sense, as meaning the great rules of arithmetic. So Johnson in his old dictionary gives *algorithm*, or *algorism*, as the six operations of arithmetic; and the "Edinburgh Encyclopædia" has it as the rules of arithmetic, or the art of computing in some special way, and, finally, as the principles and notation of any calculus. Here we see it has sprouted and come very nearly into its present acceptation, in which I would define it as the fundamental operations of an algebra with their assumed laws and notation. In the algebra of natural number there are seven such, for we put in one more since the days of Samuel Johnson. As illustrations of simplicity and seeming insignificance, let me call your attention a moment to the three direct operations, which you have always known.

Suppose in counting we make a mark for each thing and connect them by Stifel's sign of addition, $1+1+1 \ldots\ldots +1$. Then, if we go over them one, by one we have a mark to register our result. But, even without taking the trouble to count them, we can say they will amount to some number and call it "a." But suppose we have to count a lot of the same sort of rows all equal, we know that an actual count will give for each the same number which we have called "a," and we will get a as many times as we have rows; that is, a number of times, say b times, and the grand total will be a taken b times, or ab. But suppose the number of rows should be equal to the number of columns,

then we would have a times a, or $a\,a$; and in the same way we might have a times $a\,a$, or $a\,a\,a$, etc. But why write all the a's? Put one and a number above to right to tell how many, call the number b, and we have a^b.

These are the three direct operations, seemingly mere devices to spare a little trouble. You could hardly believe the conquest of the thought-world was lying dormant in them. Yet their undoing or inversion leads to the four inverse operations, and the seven, together with their working laws, are the algorithm of your algebra. So are they also of Descartes's application of algebra to form, and even Newton's fluxional calculus to a certain extent presupposes them, so that it was looked upon rather as an extension, a generalization, than as a new algebra of infinitesimals formulating its own working algorithm.

Therefore, much as we prefer Newton's character, and believe in his prior invention of the calculus, it is to Leibnitz that we assign the high honor first to have grasped the plural whose growth we are illustrating. After two of the most extraordinary of modern algebras were discovered and published, it was found that the possibility of each had been indicated by Leibnitz more than a century and a half before.

Toward the modern deep study of the formal laws involved in a pure science, Lagrange and Laplace led on also by the conclusion that theorems proved to be true for symbols representing numbers are also true for all symbols subject to the same laws of combination. Hence followed the principle of the separation of symbols of operation from those of quantity, with the "calculus of operations." The world of mind had now developed sufficiently to appreciate the definition of *an* algebra, though when it was first given I do not know. An algebra is an abstract science or calculus of symbols combining according to defined laws. There may be an indefinitely large number of sets of such defined laws—that is, of distinct, different, and independent algebras.

In the history of science it is a worthy illustration of the rhythmic character of great advance that, as if by an irruption of genius, the same year (1844) published three of the most fundamentally new and interesting modern algebras, and stamped for immortality the names of Rowan Hamilton, Hermann Grassmann, and George Boole.

Among the first men to systematically consider symbols combining according to laws more complicated than those of natural number was Sir Rowan Hamilton. After a struggle of ten years from 1833, his genius enabled him to escape from the rut of common thought by casting away the commutative principle in multiplication, which in numbers formulates the fact that twice three gives precisely the same result as thrice two. So, in 1843, he presented to the Irish Academy the principles of the algebra of quaternions, and published an article on the subject in the "Philosophical Magazine" in 1844. At the same time had appeared in Germany Grassmann's "Ausdehnungslehre," a more extraordinary algebra, which contains quaternions as a special

case. But let me pause here. We have sufficiently shown our plural without even mentioning Cayley and Sylvester's invariantive algebra; Riemann's theory of a complex variable; the algebra of polar elements; or any of the many others that have sprung or are springing into being.

As for pluralizing the idea of space, that would follow very briefly if only I might talk in terms of the "Ausdehnungslehre." Quaternions, as Professor Tait has said, is content with one flat space; but Grassmann, in a little appendix of only two pages, has shown the ability of his extensive algebra to cope with the modern double plural of the old idea of space. Before this idea had germinated, while therefore there was no real use for the word "spaces," the parsimony of language applied it to mean *pieces of space;* but in the fullness of time it has received its heritage, and by spaces I mean an aggregate of which the space hypothetically infinite and containing the material universe is but one. A statement in the technical terms of analysis would probably tend very little toward clearing up this matter to one not already familiar with it. Let us, then, use rather the historical method—attack in the light of history.

As an eternal treasure and model to the world the Greeks bequeathed the synthetic science of a space. This is the particular space in which you believe, and are sure you and the stars are inhabiting. You will be glad to know that it has been made a fitting monument to the writer of the greatest classic, and inscribed with the name of Euclid. This Euclidean space is a tridimensional homaloid, and so, in distinction from it, spaces with positive or negative curvature are called non-Euclidean.

Through all the centuries up to the present Euclid's space contained at least the thought-world. The space analyzed in Euclid's "Elements" was supposed to be the only possible form, the only non-contradictory sort of space. And, after more than twenty centuries, it is to a little point in that same book that the new idea attaches itself and sprouts into being. This slender link is one of Euclid's postulates, misplaced in the English editions as the twelfth axiom. As the last of his six *αἰτήματα* (requests) Euclid says: "Let it be granted that if a straight line meet two other straight lines, so as to make the two interior angles on the same side of it, taken together, less than two right angles, these straight lines being continually produced shall at length meet upon that side on which are the angles, which are together less than two right angles." This somewhat complicated so-called axiom is only the converse or inverse of proposition seventeen, that "any two angles of a triangle are together less than two right angles," a theorem readily demonstrated from the preceding postulates and axioms. An inverse is usually exceedingly easy to prove. Then why not remove this inverse from among the postulates, place it after seventeen, and demonstrate it? This obvious way to improve on Euclid suggested itself to nu-

merous geometers throughout the centuries. Hundreds tried it, and failed. As in squaring the circle, some claimed to have accomplished it; but against each one all the rest decided.

It now seems queer that no one during all this time systematically developed the results obtainable when this postulate is denied, is negatived, is thrown overboard. Euclid's method, the *reductio ad absurdum*, would have led them on to this if only it had ever entered their heads to suspect a plural to space. But the perfect originality of this step required genius, and has given a permanent rank in the history of science to two names of which otherwise we should probably never have heard, Bolyai and Lobatchewsky. Their publication of a non-Euclidean geometry gave the entire question a totally new aspect, and from that moment everything previously printed on the subject became antiquated; everything else became moribund, and the world of geometries was dualized into Euclid and non-Euclid. Like Columbus, they discovered and opened a new continent, into which for the last forty years geometers have been swarming, rewarded by many gold-mines. On non-Euclidean spaces and the kindred subject, hyperspaces, I have given in the "American Journal of Mathematics" a list of about one hundred and eighty publications since 1844. In dividing spaces with reference to the parallel-postulate, those in which through one point outside of a straight line can be drawn more than one parallel to that line are called hyperbolic spaces; that space in which through the point we can draw one and only one parallel is called parabolic; those spaces in which we can draw no parallel straight lines are called elliptic. In hyperbolic spaces the sum of the three angles of any triangle is less than two right angles, in parabolic equal to, in elliptic greater than, two right angles. Elliptic spaces are positively curved spaces, hyperbolic are negatively curved spaces, while the parabolic has no curvature, is a flat or homaloidal space.

This pluralization of the idea of space is independent of dimensionality and came synthetically. But about the same time came analytically a plural having reference to dimensions. Our perceptions, intuitions, imagings, are confined to a flat space of three dimensions, and this gives us a strong prejudice in favor of the belief that our bodies and the stars are also confined in a tridimensional homaloid. But this is simply a question of fact in the domain of physical experimentation.

How this belief might be negatived is easily illustrated. In 1872 Clifford said before the British Association: "Suppose that three points are taken in space, distant from one another as far as the sun from α Centauri, and that the shortest distances between these points are drawn so as to form a triangle. And suppose the angles of this triangle to be very accurately measured and added together: this can at present be done so accurately that the error shall certainly be less than one minute, less therefore than the five-thousandth part of a right

angle. Then I do not know that the difference of the sum of the three angles of this triangle from two right angles would be less than ten degrees, or the ninth part of a right angle." This says that it is within the power of our astronomers to discover that our space is not flat. And already spiritualists claim to have experimentally demonstrated that our space has more than three dimensions. As for myself, I admit I am prejudiced just as you are. I do not think it probable that astronomers will prove that we are living in a curved space, and everything connected with spiritualism seems to me disgusting bosh. But it is not the probability that I want. I am simply illustrating the possibility, and this is enough to bring the matter into the domain of simple external reality.

You have the meaning of a fourth dimension strikingly put before you every time you look into a mirror. There you see yourself so turned around that your right hand has become your left. If you were to step straight out of the looking-glass every one would think you left-handed. Such a change could be accomplished by revolving you in the fourth dimension, and in no other way. Therefore a mirror will show you at any moment exactly the effect of a fourth dimension. Then why is this not a proof of the actual existence of a fourth dimension? I answer that here, as in the case of the spiritualists, there is deception.

It would be proof if there were no deception. The straight rays of light break against the mirror and are turned back. Our eyes give us no account of this break and turn, and so deceive us, putting before us, like the spiritualists, the effect of a fourth dimension. These are not questions which can be decided by reference to our space intuitions, for our intuitions are confined to Euclidean space, and even there are insufficient, approximative. For instance, you suppose you can imagine a curve on a plane, and so in physics curves are taken to represent functions. In reality you can not get any closer to it than what the Germans call a stripe. The analytical copy of the curve is not the function but the stripe.

But you may say, How can we ever go better and deeper than our intuitions? If I answer, "Logic," you are apt to feel soothed. It is wonderful what a strong though often unconscious distinction exists in the general English-speaking mind between logic and metaphysics. Metaphysics is always scorned and scouted; but if you say logic, ah! that is a very different matter. Again, I must acknowledge for myself sympathy with the general feeling. I think most metaphysics ought to be scorned; and I am glad that in English logic means formal logic, a pure science, and is rarely mixed up with a metaphysical Erkentnisslehre or *ken-lore*. To be sure, formal logic was for ages the most fixed of all things, and so fell into some disrepute, since to be stationary and unprogressive is to be so far unscientific. But at last came the awakening. In 1847 two mathematicians, Boole and De Morgan, published

works on logic. Thenceforth was no longer applicable the latter's reproach: "First, logic is the only science which has made no progress since the revival of letters; secondly, logic is the only science which has produced no growth of symbols." Among De Morgan's many gifts to advancement, perhaps we should select as most important his founding a logic of relatives. But even he thought Boole's calculus of inference the most extraordinary advance ever made in logic. At a single stroke of genius, unheralded, sprang forth an algebra of logic. This stroke shattered the imprisoning magic circle of Aristotle; and in the last few years four or five new algebras of logic, differing more or less from Boole's, have come into being; another is now being published, and I know of two more preparing. I will not attempt here any explanation or eulogy of what has been thus accomplished for logic. This can already be found in English, French, and German. Modern logic will date from Boole.

But I wish to call attention to the fact that here we find the best, the most satisfactory introduction to the study of modern algebras, modern mathematics. When told that in these systems a product may not vary with each of its factors; that a product may vanish without either of its factors vanishing; that subtraction and division may be indefinite; that, in fact, any system, e. g., quaternions, where the products and powers of the units are themselves linear functions of the units, excludes the ordinary assumption that a product shall vary with each of its factors; that from $q\,q, = o$, it does not follow that either $q = o$ or $q, = o$; that a quadratic equation, e. g., in quaternions, besides its sixteen roots proper, may have an indefinite number of roots which arise from the fact that the process of division is not a definite one; when told these, and very many more such, the beginner is only too sure to think, "This is a hard saying," and may give up the subject in hopeless confusion. If, however, he will start with Schroeder, "Der Operationskreis des Logikkalkuls," he will find the clearest explanation and illustration of these things contained in his own every-day thoughts about the commonest objects; and, while learning an elegant logic, will be mastering, perhaps, the most exquisite dual algebra.

CHEMICAL EXERCISES FOR ORDINARY SCHOOLS.

By ELIZA A. YOUMANS.

PROFESSOR RAINS'S little book for beginners in analytical chemistry has been already noticed and commended in these pages, but its method is so excellent that it needs to be more fully explained.

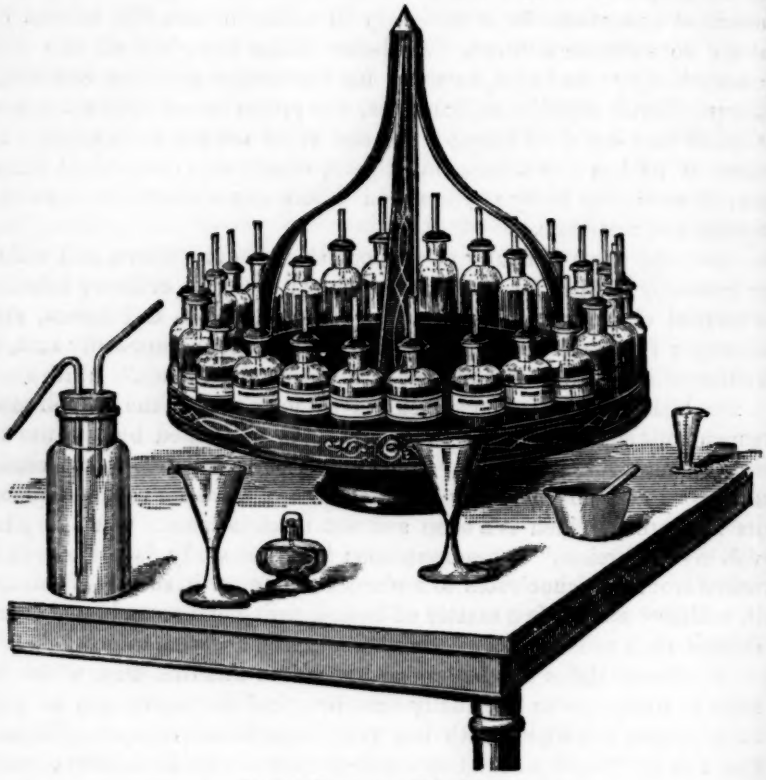
Chemistry is now a regular study in many if not in most schools;

but, in the common mode of pursuing it, the pupil gets but very little real knowledge of the subject. He reads about it; learns lessons upon it; works out chemical calculations for examination; and, perhaps, sees some lecture-room experiments. He acquires some general ideas, but he gets very little actual, thorough, practical knowledge of the properties of chemical substances, and no such familiarity with chemical operations as is necessary in order to turn this branch of study to valuable account. Professor Rains saw that all this was unsatisfactory; and that, to make his knowledge good for anything, the pupil must experiment, must test the properties of substances, and himself find out how they behave and react toward each other. In short, if he has any honest, intelligent, educational purpose in view, he can only gain it by practice and direct experience with chemical agents and materials.

But there is a difficulty at the outset met everywhere, and which is generally fatal to all thorough chemical study in ordinary schools. Practical chemistry is dirty work. It makes slops and fumes, and damages furniture and clothing, and, as has been graphically said, it is altogether an unsavory affair of "messes and stenches." With such a reputation it is, of course, held to be unsuited to the schoolroom, which indulges no further in dirt than is compelled by the use of chalk and the blackboard. In this respect school habits are established. Practical chemistry must, therefore, have its separate place, its laboratory, which is a shop and not a schoolroom. Chemistry involving "exercises," or manipulations in object-study, is therefore expelled from the schoolroom to a place fitted up for it, so that chemistry in ordinary schools is a matter of book-learning and second-hand information, such as is now correctly characterized as "sham knowledge."

Professor Rains has addressed himself to this difficulty, which he aims to overcome so effectually that practical chemistry may be pursued almost anywhere with but very little inconvenience. He saw that this is the first and indispensable step to success in making chemistry a real branch of common education; and he accordingly set himself to contrive a little compact, portable laboratory, such as can be readily used anywhere, and would at the same time prove adequate for the uses of the student. And he has well succeeded in his object. The accompanying woodcut represents his device. It consists of a revolving test-stand, twenty or twenty-four inches in diameter, made of galvanized iron or strong tin-plate, so as to hold a large number of test-bottles, containing the reagents for analysis. These bottles stand side by side, and are kept in position by an outside and inside rim, soldered to the circular plate. There is a hole in the center of this plate, and a tube, fifteen inches long, has its lower end soldered above it, the upper end being closed. An iron rod, screwed into a stand or base, and conical at the top, passes up through the tube and supports the whole upon its point. To stiffen the arrangement, three bent strips

of tin are fastened to the top of the tube and to the inner rim, as shown in the woodcut, where the middle strip conceals the central tube. There is room inside the circle of test-bottles to place the other bits of apparatus when not in use. The whole construction occupies but a small space, and can be conveniently set aside when not required,



RAINS'S REVOLVING TEST-STAND.

or left in any corner or closet, and covered by a piece of cloth, to protect it from dust. For practice it is placed on any common table, and two pupils can readily use it at the same time from opposite sides. It turns so easily that any test-bottle wanted can be taken and directly returned to its numbered place, so that it is kept constantly in order for continued exercises.

It must not be supposed that this is merely a nice plaything to enable boys and girls to make amusing chemical experiments. Professor Rains had a very serious purpose in preparing it; and it is designed for systematic chemical work. It has been adapted to take pupils through a course of qualitative chemical analysis. Besides the necessary apparatus, there is a sufficient equipment of test-substances for

going through a full course of analytical exercises. At the very outset the pupil begins to *think*, and has to make his own way. He learns the properties of chemical bodies by trial and observation; and his progress consists in solving a succession of problems by finding out and identifying chemical elements and compounds. Some seventy or more simple salts soluble in water are the substances chosen for examination, and these are first tested to find the base or metallic component of the salt, and then to find the acid or electro-negative element. It is a work of investigation from the start, and what the pupil learns he *knows*. There are no recitations, the evidence of proficiency being what the pupil can *do*. The course is one of self-instruction, and its value depends upon the principle that one difficulty overcome by the pupil himself is of more educational benefit than a score of difficulties over which he is helped by others. Professor Rains's little accompanying manual begins by explaining the use of the necessary apparatus, and then the inquirer is directed how to enter upon his regular work; but, the problems being presented in order, he is left to solve them himself, which is the only way in which he can become a chemist.

Nothing so neat, compact, and convenient as this mechanical arrangement has ever before been furnished for beginners in analytical chemistry. The method has grown out of Professor Rains's experience as a chemical teacher; and only by a long course of assiduous trials with students and classes could he have succeeded in putting into such small compass, and such a portable and convenient form, the facilities of manipulation by which a practical foundation in the knowledge of the science can be laid. In his annual course of lectures upon "Physics" and "Chemistry" at the Medical College of Augusta, Georgia, Professor Rains has among his students the senior class of Richmond Academy, an institution in which for several years he has been the teacher of Natural Science. As a result, he became convinced that a much larger amount of chemical study than is commonly supposed, and that, too, by direct chemical work, might be given to the senior classes of ordinary schools where there is no laboratory, and no specially qualified chemical teachers. He was so sure of this, and so impressed with the value of practical work in chemical analysis—the most interesting of all chemical practice—that for several years he has given the senior academy class a certain amount of chemical testing to do by themselves, furnishing them only with simple apparatus and clear directions. In this way the self-education of the pupils has gone forward with the happiest results. Satisfied that the same advantages may be secured by others, if they have only the requisite means of practice furnished to hand, he has constructed the little laboratory that will now be furnished to anybody by the instrument-maker.

As to what has been actually attained with classes by this method of study, Professor Rains thus remarks in his preface: "At the recent

closing exercises of the examination of the pupils of the academy, which took place at the Opera-House before a large audience, the following were the results from the chemical class of fourteen students: Samples were taken at random from the bottles of different commercial salts (single bases and acids) by one of the trustees and given to each student. Of the fifty analyses made in a little over one hour, not a single failure was made. The class had studied theoretical chemistry for seven months three times a week, one hour's recitation each; after which they had table-practice for eight weeks, or twenty-four school-hours; to which as many more were voluntarily added by the students after school, making forty-eight hours in all of analytical work."

This brief statement is full of important suggestions. The preliminary study of theoretical chemistry for seven months, probably in the ordinary way of lesson-learning, was, no doubt, somewhat helpful; and it would be well for all pupils, in entering upon a course of exercises in analysis, to be possessed of some elementary chemical ideas. But the practical experience of actual investigation is so much a thing by itself, that those who have read up do not really have the great advantage over beginners that might be supposed. The pupil who goes to work fresh will very soon get the elementary conceptions needed, and he will then read chemistry with redoubled interest, and to better purpose.

But what is significant in this case is that, when the pupils came to practical work, they voluntarily doubled their tasks, and this, too, notwithstanding the "hardness" of exercises that had to be mastered unhelped. The mode of study was attractive because there is no pleasure like the sense of power that comes from conquest. There is, moreover, a fine satisfaction in that free play of the faculties which self-instruction implies; and Professor Rains says, "The students are allowed entire freedom while at work." The superiority of this mode of study can no longer be questioned; and Professor Rains has done a very important service to education in thus facilitating the thorough and at the same time pleasurable pursuit of one of its most useful branches.

THE EXTREME RARITY OF PREMATURE BURIALS.

By Professor WILLIAM SEE, M.D.

THE article on "Premature Burials," in the January (1880) number of this journal, from its tendency to magnify the importance of the probabilities of premature burial in cases of trance and suspended animation, and from its assertion that, in effect, the ordinary physician or general practitioner is not capable of reaching a

satisfactory conclusion upon the signs of death, has led the writer to brief in what follows the opinion of the medical jurists of the present day upon this subject. That the trance state has been mistaken for death, and that premature burials have taken place, seem to be fully recognized in the system of morgues or dead-houses in various parts of Europe where bodies are so placed that the slightest movements will be brought to the notice of attendants; and in the laws which in most countries require the lapse of twenty-four hours and longer periods between death and burial. Yet competent authorities tell us that such institutions (morgues) are superfluous when ordinary care is taken by the relatives of a deceased person; and Taylor says that he has never met with any instance in which a body laid out in them was resuscitated after there had been a proper verification of death.*

In discussing this subject, how far are we justified in taking the statements of the earlier writers? The credulity of the public in similar matters is sufficiently shown in such works as Carpenter on "Mesmerism, Spiritualism," etc., and Hammond on "Fasting Girls," to induce us to view general statements with much suspicion. M. Fontenelle has published forty-six cases of premature burial from the time of Plutarch downward. Taylor, from whose work on medical jurisprudence this article draws freely, after a careful examination of all these cases, rejects the greater number of them simply because they are drawn from such sources as to render them perfectly inadmissible as evidence. M. Carré, in 1845, published the assertion that forty-six cases had occurred since 1833. Taylor examines his cases, and finds that no particulars by which their accuracy can be tested have been given. The whole subject, as taken from the tone of the article now commented upon, and from public opinion in general, resolves itself into two statements, viz.: that it is quite possible, and has been proved, that a state of trance, prolonged and of a nature to simulate death, may exist and deceive even those whose daily avocations make them familiar with death itself; and that many cases are on record where changes in the position of the body, and even where the birth of children, have taken place after interment.

For the existence of a trance state sufficient to simulate death, all appreciable movements of respiration and circulation must be suspended for a considerable length of time, and there is but one properly authenticated case on record as accepted by physiologists; even this case will not bear too close discussion at the present day. We are told in works on physiology that a Colonel Townshend was able at will to suspend animation to the extent of obliterating any perception of the heart- or pulse- beat, and of any respiratory movement, as a mirror held over the mouth and nose showed no dimness of its surface; and further,

* Forty-six thousand bodies were deposited in the mortuary institutions of Germany during a space of twenty years.

that he was able to continue in this condition for the space of half an hour: at the end of this time gradually the signs of returning vitality began to assert themselves until a perfect restoration of the functions of life ensued. From the description generally given, we are led to suppose that this was done not once but several times, and that the subject was under careful inspection by medical men during the continuance of this state. But Braid, in his "Observations on Trance," tells us that Colonel Townshend, as a patient of Dr. Cheyne, was in the last stages of a chronic kidney-disease when, *nine hours before his death*, he made known to his medical attendant his conviction of an ability to "die or expire when he pleased, and yet, by an effort or somehow, he could come to life again." This he tried before Dr. Cheyne, with the result as just recorded. This case happened nearly one hundred and fifty years ago, and, in view of its occurring only once and under such peculiar circumstances, with no details as to the extent and accuracy of the means taken to obviate all sources of error, leaves room for the skeptic, without casting a slur upon the good name and reputation of Dr. Cheyne, to express strong doubts upon its probability.

A case which has interested the medical profession very much and is of recent date, is that of the late Dr. Groux ("Proceedings of the Medical Society, County of Kings," vol. iii., p. 350, *et seq.*), in whose person there existed from birth an opening or fissure in the breastbone (sternum) which he could extend by forcible separation to the width of two inches. He was supposed to have possessed the power to arrest the action of the heart at will—for a duration of about twenty seconds—but without any other disturbance of his usual condition. The arrest of the heart's action in this case is affirmed positively by some, doubted by others; one examination by three medical gentlemen developed no stoppage of the heart's action, but merely a stoppage of the pulse at the left wrist, attributed to the unusual mobility of the collar-bone (clavicle), by which the artery (subclavian) passing under it to the wrist was compressed.

Medical jurists, after carefully examining all evidence that can be accepted upon such cases, have concluded that it is impossible to suspend animation or to simulate the same, without detection by the *ordinary* means, for so long a space of time as one hour; and it is fair to assume that when such cases are reported they are due to gross negligence, for where the medical practitioner does his duty and calls in to his aid the ordinary means as taught in all the medical schools, of listening at proper intervals and for a sufficient length of time for the heart-beat, he will find that no heart can intermit its beats—that is, remain in perfect repose—for a space of five minutes in time. Cases are cited in newly-born children where twenty minutes have been supposed to elapse after suspension of the heart's action before resuscitation took place, but these are considered as due to imperfect or careless tests.

The respiratory movements coincide generally with the heart's action: all respiration ceasing, the heart never continues to act longer than five minutes, and these movements can be noted by the non-medical observer, by placing a piece of looking-glass, or a dish filled with water or mercury, upon the chest, and allowing the light to be reflected upon the surface; the slightest movement will result in oscillations.

A common mistake of death for a supposititious trance state is the continued or increased warmth of the body, which is so remarkable in some cases; there are instances where days have elapsed before the body was allowed to be put in the ground, because of its continued warmth, and of the absence of the corpse pallor; and again it has been frequently noted in cases of death from cholera that bodies, which at the time of death were moderately cool, have developed a temperature of 87° Fahr. and of 92° Fahr., and in cases of death from injuries to the nervous system even a much higher temperature has been reached —evidences, as Taylor puts it, of some latent vital power or chemical force still lingering about the circulating system.

While the trance state is a source of mystery and wonderment to the popular mind, the positive statements of a change of position in a body, and even of the birth of children after death, are something more tangible and real, and carry their convictions in a more decided manner. Yet these phenomena in many cases are accounted for in the most natural way. There is inherent in the muscular tissue of our bodies a certain irritability or tonicity—vitality, perhaps, is a good expression —of the muscle itself, which is independent of the brain, nerves, circulation, or respiration, in that it continues to exhibit its function—that of muscular contraction—for an appreciable time after death has abolished these forces, and physiologists, by supplying the muscles with nutrition, such as the injection of defibrinated blood, have been able to excite this irritability so late as sixteen hours after death. It is this irritability which results in the *rigor mortis*, or rigidity of death, and which sets in generally within five or six hours, lasting from sixteen to twenty-four hours. With this rigidity is a muscular contraction usually not resulting in any change of position of the body; but the flexor muscles exhibit a greater tendency to contraction than the extensors, and there are instances where this contraction has been quite marked, resulting of course in a change of position. If a body be not properly laid out and placed in a coffin in the cramped position in which *rigor mortis* has set it, there will necessarily be some change of position when, at the end of the time mentioned, this condition passes off and a relaxation ensues. In one case of death from cholera, half an hour after complete cessation of circulation and respiration, the muscles of the arms underwent spontaneously various motions of contraction and relaxation, continuing for upward of an hour.

The fact of finding a dead child lying by the side of its mother in

the coffin, with the knowledge that it was born or extruded after interment, must have a startling effect upon the ordinary bystanders, yet Dr. Aveling ("Obstetrical Transactions," London, 1873) has reported thirty cases where the expulsion of the child was due "either to a contracting power remaining in the uterus after the death of the rest of the body, or to the pressure exerted on the uterus by the gases of putrefaction, the latter being the more frequent cause."

The only motive in preparing this paper has been, not to contradict the fact that premature burials may have taken place and under the most unhappy circumstances, but to place renewed confidence in the ability of the *ordinary* general practitioner of medicine to recognize the distinction between a state of trance and a state of death, and to induce a disregard of the idle stories of ignorant and superstitious persons upon premature burials.

THE ST. GOTHARD TUNNEL.

THE boring of the St. Gothard Tunnel is pronounced by one of the engineers to be the greatest work hitherto attempted by man; certainly its importance and magnitude can hardly be overrated. It deserves to be regarded with especial admiration as a work which was marked in every department and at every stage by triumphs of the highest skill in scientific engineering. The tunnel is intended to form part of the railway connecting the North Sea with the Mediterranean, and is situated on the most direct route between these regions, passing through the chain of the Alps at a central point. The railroad through this line was preceded by the road over the Brenner Pass of the Tyrol, for that was easier of execution, and by that through the Mont Cenis Tunnel, for the French Government had political reasons for constructing a road which should be under its own control. The Swiss soon saw, after the rival lines were constructed, that the traffic which belonged to them would be diverted to pass around them, and immediately began operations to open a road through their own most direct route. In this they enjoyed the coöperation of Germany and Italy. The operations at St. Gothard were begun under the advantage of the possession of the experience, knowledge, and skill that had been gained in constructing the tunnel of Mont Cenis.

The preliminary surveys made it certain that the only points at which the opening of the tunnel could be made were near Goeschenen, in the Canton Uri, on the north, 1,109 metres or 3,604 feet above the sea, and near Airolo, in the Canton Tessin, on the south, 1,145 metres or 3,721 feet above the sea. Considerable works were necessary to reach these elevations. An examination of the map showed that the tunnel might be straight and that it would be about 15,000 metres or

48,750 feet long. The engineers of the tunnel of Mont Cenis had a point at the highest part of the ground from which they could see at once objects indicating the positions of both openings. No such advantage existed at St. Gothard, and some of the summits are so steep

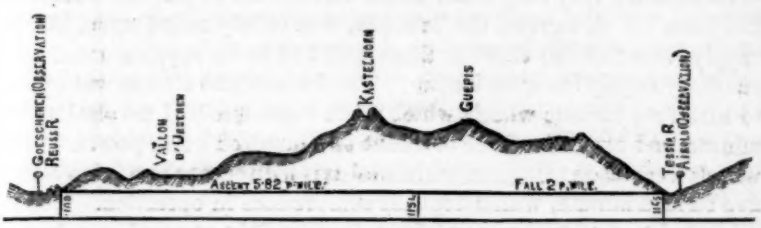


FIG. 1.—PROFILE ALONG THE LENGTH OF THE TUNNEL.

and high that it is impracticable to attempt any direct tracing of the line over the mountain. The relative position of the two openings and the direction of the tunnel had then to be calculated indirectly, from triangulations. The directions and levels were thus ascertained. Observatories were then placed at the tunnel-mouths to serve as direction-points for the miners. At Goeschenen it was necessary, in order to get a long enough line of sight, to make borings of considerable length through two projecting rocks. The surveys, originally made by M. Gelpke, were verified by a second series of triangulations made in 1874 by another engineer, M. Koppe, on a different system. M. Gelpke had based his surveys on summits in the neighborhood, and had used triangles of only moderate size. M. Koppe made his triangles as large as possible, so that he might connect the two openings of the tunnel by a minimum number of intermediary stations. The two triangulations gave results agreeing within two seconds of direction with each other. M. Koppe also verified his survey practically by projecting a line from the opening at Airolo toward a mast which he set up at the highest attainable point along the axis of the tunnel. He could not go toward this point from Goeschenen, so he went backward in the direction of the continuation of the tunnel-axis, ascending the flanks of the mountain till he could observe his mast. Then, having directed his glass toward Goeschenen, he raised it vertically to the level of the mast, when he saw it almost in the center of his field of vision. The direction within the tunnel was verified by means of field-glasses fixed within the observatories, so far as they would answer, then by means of lamps hung on the line of the axis. The direction was, moreover, carefully verified from the observatories two or three times a year.

The borings were made almost entirely by machines, and it was the policy of M. Louis Favre, the contractor for the tunnel, to dispense with hand-boring as far as possible. The machines were driven by water-power transmitted into the tunnel by means of the compressed-

air apparatus of Professor Colladon, of Geneva, which had already been used at Mont Cenis. Water was obtained in great abundance and of strong fall at Goeschenen from the river Reuss. The supply of water at Airolo was not so abundant. The river (the Ticino) has not a rapid descent, and a very long canal would be required to procure a sufficient fall from it. A torrent, the Tremola, was chiefly relied upon, but the supply from this fell short at times, and had to be supplemented by an auxiliary supply from the Ticino. The force of the stream was applied to turn four turbine wheels which made three hundred revolutions in a minute, and exerted a force of about two hundred horse-power. These wheels were made to turn an horizontal axis with cranks revolving eighty-five times a minute, which kept the compressors in operation. The air, subjected to a compression of from four to eight atmospheres, became very hot, and had to be cooled by special applications of water circulating in cold currents around the pumps and in the pistons and piston-rods, and by injections of fine spray. After being further cooled and freed from water in suspension by passing it through reservoirs, it was conducted into the tunnel by tubes which were of considerable size at the beginning, but were diminished to correspond with the diminishing expenditure of air as the work was advanced.

The borings were begun by first cutting out a gallery about eight feet square at the top of the intended excavation. When this advance boring was completed, it was enlarged on the right and left. The arches of the roof were then built, and a trench nearly ten feet wide was dug to the level of the tunnel's base. This was called the "Cunette de Strosse." All that remained on the right and left of the

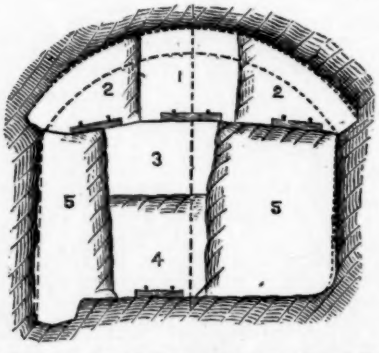


FIG. 2.—SYSTEM OF EXCAVATION: 1, advance gallery; 2, side-workings; 3, 4, "Cunette de Strosse"; 5, "Strosse."

trench, called the "Strosse," was next removed. Thus, most of the digging was done downward. The work was interfered with at times by the infiltration of water, which, as it did not affect dynamite and soon stopped, was not considered serious; by rocks of exceptional hardness; and by a bed of loose material in the Goeschenen end, in which

it was dangerous to work for fear the mass would fall and bury the workmen, and cut off their retreat. Communication was opened between the two galleries on the 29th of February, 1880. The chief miner on the southern (Airolo) side had pierced an horizontal hole about ten feet long, and had caused the attacks from the side of Goeschenen to be suspended on his penetrating to the northern gallery. Proceeding with a boring of moderate depth, he reduced the thickness of the remaining mass to about four feet. Preparations were made for the final attack by piercing four holes in the center of the boring, and eleven other holes at equal intervals around it and not very far distant from it. The explosion opened a passage of a little more than thirty inches in diameter, through which the engineers and some of the workmen were able to go over from one gallery to the other. When the communication was first opened, at eleven o'clock in the morning, the barometer stood .156 of an inch higher at Goeschenen than at the southern end of the tunnel. A current of air was immediately produced in the gallery, which blew at the opening at the rate of a metre and a half (nearly five feet) a second. A few hours later the relative pressure was reversed, and the barometer stood .039 of an inch lower at Goeschenen than at Airolo. The direction of the current of air was consequently changed; it blew from south to north, but at the rate of only about a foot in a second. The actual length of the tunnel was about twenty-five feet shorter than the calculated length. The difference in the level of the two galleries was not more than four inches, and their lateral deviation was not more than eight inches. According to a statement made by M. Colladon to the Academy of Sciences at Paris, the most efficacious means adopted to speed the work of excavation were the diking of the torrents and the application of water collected in aqueducts as a moving power to turbine-wheels requiring high falls, the adoption of air-compressors which worked with great rapidity, the cooling of the air in the compressors, at the moment of compression, by the injection of water in a fine spray, the use of dynamite, and the determination which was adopted from the beginning to carry on the excavations from the top of the tunnel. By the aid of these improved methods the advance through the hard rocks was made with double the speed that the engineers in charge had been able to attain in boring the Mont Cenis Tunnel. It is estimated that, notwithstanding its greater length, the tunnel of St. Gothard when completed will have cost from twenty-five to thirty per cent. less than that of Mont Cenis.

The provisions for conducting compressed air into the galleries, involving a system of pipes upward of sixteen thousand feet long in each gallery, afforded excellent opportunities for studying the flow of compressed air through metallic conduits. The loss of air in passing through the pipes was an important factor. The absolute pressure of the air, which was equivalent to six and a half atmospheres at the

Goeschenen mouth, was diminished till it became, toward the end of the work, no greater than one atmosphere and an eighth at the front of the cutting. At Airolo it was necessary to enlarge the diameter of the perforators, and a much larger volume of air had to be spent to do the same work. The temperature at the front of the excavations rose to 91° during the last days of the operations, and greatly taxed the endurance of the workmen. Calculations have been made to the effect that, taking the work all through, each kilogramme of dynamite that was used corresponded with a cubic metre of rock that was removed. Among the gains to engineering which, it is claimed, have accrued from the enterprise, are the perfection of the machinery and tools for boring, and the training of a body of skilled workmen, who have become experts, able to determine, by merely inspecting a rock, how to deal most efficiently with it. The perforation of tunnels will in the future be a simpler, easier, and less costly operation than it has been heretofore. Since communication was established between the two galleries of the tunnel, a part of the mountain mass, 6,300 metres, or 20,475 feet from the southern entrance, has fallen in, killing and injuring several of the workmen.

M. FOUQUÉ'S SANTORIN AND ITS ERUPTIONS.

M. FOUQUÉ, a professor in the College of France, has recently published an elaborate work on the volcano of Santorin, which is considered one of the most remarkable and instructive examples of volcanic phenomena on the earth. He possesses excellent qualifications for this work, for he has made special researches on the volcano on three different occasions: first, when sent by the French Academy of Sciences in 1866; and twice afterward, in 1867 and 1875, under a commission from the Minister of Public Instruction. His account embraces the detailed recital of the observations which he made on the ground, and the description of his labors in the laboratory, analyses, and microscopic examinations, and contributes much to our knowledge on mooted questions respecting volcanic action.

The products thrown out in the recent eruption—which took place in 1866—like those of most other volcanic manifestations, may be divided into two categories: 1. Volatile matters exhaled in the form of gases and more or less easily condensible vapors; and, 2. Lavas overflowing in imperfect fusion, or thrown out as ashes and scoriæ. The gases varied greatly in composition during the course of the eruption. At the beginning, when they had not been subjected to the action of the air, they were rich in combustible elements, particularly in free hydrogen, arising in some cases from the separation of

water into its two elements. At a later stage, the gases varied incessantly in composition, and the combustible elements at last entirely disappeared. The emitted gases consisted chiefly of free hydrogen, marsh-gas, hydrochloric, sulphuric, and carbonic acids, sulphuretted hydrogen, and nitrogen. Water played a prominent part in the different phases of the eruption. In the state of vapor it was present in all the emissions of volatile matters whatever was their temperature, and it might be regarded as the immediate cause of the explosions. No dry smoke-vent was observed. Coming in its liquid state from hot springs, the temperature and flow of the water varied with the state of the sea.

Chloride of iron, expelled as a vapor, was found associated with hydrochloric acid; but the hydrochlorate of ammonia, commonly abundant in eruptions, was almost wanting. This fact lends support to the opinion that the ammoniacal product of volcanoes is of organic origin, and is brought by the atmosphere over vents charged with hydrochloric acid. The distance and the small extent of cultivated lands explain the rarity of ammonia in the air at Santorin.

Over the central eruptive mouths, the points of the volcano where the incandescence was most lively, the spectroscope showed the presence of volatilized salts of soda and potash. After the eruptive manifestations had ceased, the salts which were deposited around the orifices of the vents were collected and analyzed, and appeared to consist largely of the chlorides of sodium and potassium, the sulphates of soda and potash, and the carbonates of soda and magnesia. Sea-water after evaporation leaves a residuum of analogous composition. These results are interesting in their bearing on the theory that the water of the sea is the immediate ordinary agent of the eruptions. All of the elements usually occurring at volcanic vents were found to be present at the points which were the seat of a volatilization of alkaline salts, lending support to the opinion which had been previously drawn from studies made at Etna, that the vents at their highest temperature present at once all the chemical elements of the volatilized bodies in the volcanoes, and that the cooler vents are gradually impoverished as their temperature becomes insufficient for the reduction of the eruptive materials to vapors.

Some of the volatilized substances in the volcanic conduits are susceptible of reacting on each other and producing fixed compounds. Thus are engendered the hydrated oxides of iron, specular iron-ore, free sulphuric acid, alum, and sulphate of lime, which are met around the vents.

Certain crystallized silicates, however, generally originate under different conditions. Although they are formed of elements which we are in the habit of considering fixed, they are found in the volcanic vents, on the surface of the rocks, under such conditions that they could have been produced only through volatilization. Such silicates

have been gathered at Santorin in the interior of tubular cavities like fulgurites, which have evidently been traversed by vapors at a very high temperature. The deposited crystals are of anorthite, sphene, and pyroxene under the forms of fassaïte and augite.

Other crystallized silicates are met occasionally in the lavas. They arise from the transformation of the calcareous masses which are taken from the subsoil in the region and carried out in the lavas, and consist chiefly of anorthite, fassaïte, the melanite garnet, and Wollastonite. The quartz and mica-schist, which, like the limestone, appear as inclosed lumps in the lava of Santorin, do not seem to have suffered any action from the matter surrounding them, notwithstanding the high temperature it possessed.

The mineralogical study of the lavas of 1866 offered great difficulties, on account of the small size and strong adherence of the mineral integrants. It was not practicable to extract the crystals by picking them out, and M. Fouqué was obliged to seek new processes. One, founded on the employment of a powerful electro-magnet to draw out the ferruginous minerals, permitted the isolation of the feldspar; and other minerals, harder to deal with, were separated by the use of concentrated hydrofluoric acid.

The crystallization of minerals in the recent lava took place in two stages. In the first stage were developed crystals which frequently attained the length of about a fiftieth of an inch, and of which the other dimensions exceeded a tenth of that size; and, in the other stage, crystals of notably small dimensions were produced. The latter crystals, or microliths, unite the others and follow their contour. Before the microscope was applied to the study of the rocks, only the larger crystals were recognized, and the matter which in volcanic rocks envelops crystals large enough to be perceived through the glass was supposed to be wholly uncrystalline. In this matter, however, the microliths abound in immense quantities. The discovery of them has been one of the most signal triumphs of microscopic micrography.

The minerals observed in the microliths of the general lava of 1866 are feldspar and titaniferous oxide of iron. The predominant feldspar in large crystals is the labrador, but anorthite, and some oligoclase and sanidine are also found in the same condition. The microlithic feldspar is albite with a considerable proportion of oligoclase, and the whole is cemented with a vitreous matter which represents the residue of the crystallization, the part of the rock to which the latter owed its fluidity, at the moment when the minerals which had made a portion of it were already crystallized. This amorphous matter is of a composition similar to that of albite, but a little richer in silica and potassa; and it is curious that a substance of such a composition should have constituted the part of the rock which remained longest melted.

The order of crystallization of the minerals was as follows: 1. Magnetic oxide of iron in large crystals; 2. Apatite; 3. Silicated magne-

sian irons (augite and hypersthene); 4. Feldspars in large crystals; 5. Microlithic granules of titaniferous oxide of iron; 6. Feldspathic microliths.

The general lava of the eruption of 1866 contains as inclosed masses lavas, the mineral composition of which differs considerably from that of the medium which surrounds them, of types which have a considerable part in the constitution of the ancient lavas of the volcano. The minerals of the recent lava are generally penetrated by foreign matters, microscopic inclusions which are sometimes crystalline, sometimes composed of amorphous matter. The latter inclusions are portions of the surrounding matter which remains inclosed in the crystals at the moment they are formed, and nearly always contain a bubble of gas, in which M. Fouqué found minute quantities of matter analogous in its properties to organic matter. Jets of ashes were cast out in many of the spurts of the eruption. These ashes are lava pulverized by the quick passage of gases and vapors through it while it was still more or less fluid. Its condition as to crystallinity depends on the condition of the lava at the moment it became an ash. The more fluid the lava, the more like pumice is the ash. If the lava has become charged with crystalline substances, especially if they are microliths, the ashes will offer the same characteristics. In the present case the ashes, being derived from lavas which were so crystalline that they were hardly fluid, were rich in crystals and microliths.

Remarkable movements of the soil have been produced by the eruptions within a limited space around the principal cones of the volcano, and have notably modified the surface of the land to that extent. These manifestations have always been special subjects of study with geologists.

Besides the phenomena already described, the complete development of an eruption involves: 1. The opening of the ground; 2. The formation of a cone or crater; 3. The production of a stream of lava. All these manifestations took place during the last eruption at Santorin. Eruptions analogous to those of 1866 have taken place in the Bay of Santorin since the beginning of the historical period, and have given rise to the islands which are known as the Kamenis. The bay itself was created by a catastrophe which was anterior to history, for no writer of antiquity mentions it. Yet remains of habitations have been discovered in the lava, with numerous objects and domestic utensils, which lead to the conclusion that a civilized population, who had already developed artistic tastes, were its witnesses and victims. Judiciously conducted excavations and microscopic examinations of their potteries have furnished much information concerning these ancient people. They were laborers and fishermen; they had flocks of goats and sheep, cultivated grain, made meal, extracted the oil from olives, wove cloths, fished with nets, and lived in houses with walls of squared stone and wooden beams. Most of their tools were of stone, the com-

mon ones of lava, others of flint or obsidian. They were acquainted with gold and probably with copper, but those metals were rare with them. Woods were abundant, although there now exists only a single tree, a kind of palm, in all the archipelago. The vine, which is now cultivated almost exclusively, seems to have been unknown at that period.

The islands of Théra, Thérasia, and Aspronisi are the remains of a large island which existed before the formation of the bay. Their soil is composed of three classes of rocks: metamorphic rocks (marbles and mica-schists), volcanic rocks of subaërial formation, and volcanic rocks of submarine formation. Volcanic products of subaërial formation are the only ones in view in the larger part of the group. They appear as compact lavas, scoriæ, pumice, and in dikes. Fragments of the rocks in the dikes have been subjected to examination like that which was given to the lavas of the recent eruption, and the study has been applied to the solution of the problem of the specification of the triclinic feldspars. By it M. Fouqué has been led to conclude that the four varieties so described are distinct.

M. Fouqué accounts for the origin of Santorin by supposing that there was an island composed of marbles and mica-schists, against which submarine eruptions took place; a considerable upheaval then occurred. The eruptions having become subaërial, masses of matter were thrown out from different vents, and produced a large island, the slopes of which became wooded and its valleys fertile, while its summits continued to be rugged with lavas. A violent convulsion, accompanied and followed by formidable explosions and showers of pumice, hollowed out the bay. Finally, eruptions which have taken place since the beginning of the historical period have produced the Kamenis.

The phenomena of this volcano, which is one of those that were cited by Leopold von Buch, the principal advocate of the theory, as examples of the mode of formation which he suggested, have been carefully studied in view of their bearing upon the theory of craters of elevation. They appear, in the light of M. Fouqué's investigations, to contradict this theory at every point, to sustain the old arguments which have been brought against it, and to offer other features which are irreconcilable with it; so that the conclusion is reached that the theory must be definitively abandoned.—*Revue Scientifique.*

BIOGRAPHICAL SKETCH OF FREDERICK WÖHLER.

By Professor CHARLES A. JOY.

FREDERICK WÖHLER, the Nestor of German chemists, was born July 31, 1800, in the little hamlet of Eschersheim, near Frankfort-on-the-Main, in the house of the village pastor who was his uncle by marriage. How it happened that the mother was away from home at such an important period—for this was not her residence—is worthy of record, as it shows that there were heroic elements in the family for the son to inherit. The father held the office of equerry to the Elector of Hesse-Cassel in the early part of this century. This Elector is celebrated in history for the violence of his temper. He was one day visiting the royal stables in company with the equerry, and on this occasion was so particularly insulting and unreasonable that, endurance having ceased to be a virtue, Wöhler seized a horsewhip, and then and there gave his Royal Highness such a castigation as he had often enough richly merited, but doubtless never expected to receive. The equerry then jumped upon the back of the fleetest horse in the stables, and, accompanied by a groom who was to return the steed, soon put a safe distance between himself and the impending wrath of his sovereign. The august Elector, fearing ridicule, thought it wisest to let the matter drop, and never pursued the fugitive. It became necessary, however, for the family to make a hasty retreat from Cassel, and the wife took refuge in the house of her sister, where she remained until the birth of the subject of our sketch. The parents subsequently purchased a small estate at Rödelsheim, where they resided until 1812, when they removed to Frankfort.

Frederick's first instruction in writing, drawing, and later in French, was imparted by his father, who was a university-bred man of unusual intelligence. When he was about seven years old he attended the public school, and received, in addition, private lessons in Latin, French, and music. A fondness for experiments and for making collections early manifested itself, and was judiciously encouraged by his father and an intimate friend who had, in the capacity of private tutor to a nobleman, spent some time at the University of Göttingen, and had, while there, devoted special attention to the study of the natural sciences. This friend owned considerable chemical and physical apparatus, with which he exhibited experiments to the boy, and also allowed the youth to practice his skill, particularly with the battery, which was the great novelty of the day. In addition to these experiments, all sorts of minerals which presented any peculiarity of appearance were collected for future examination.

In 1814 Wöhler entered the high school (gymnasium) at Frankfort,

where he prepared for the university. Among his teachers at the gymnasium were several men who afterward became renowned for their learning and special acquirements, namely, F. A. Schlosser, Grotifend, and Carl Ritter. The boy was faithful in his attendance upon the exercises of the school, and satisfactorily passed all of his examinations, but was not distinguished for much knowledge of the ancient languages; indeed, his passionate love of the chemical and physical sciences and his zeal in collecting minerals absorbed so much of his time and tempted him so frequently to neglect both the classics and mathematics that private tutors were occasionally necessary to coach him over difficult passages or knotty problems. He kept up a system of exchange of minerals with his fellow students, and with dealers, especially with Hermann von Meyer and with Herr Menge, in Hanau, to the latter of whom he carried many a bagful of hyalite collected by himself. An important influence was exerted upon the scientific bent of his mind by Dr. Buch, a very intellectual and learned man, who occupied himself largely with chemical, physical, and mineralogical studies, with whom Wöhler enjoyed for years a most instructive intercourse, and to whom he subsequently expressed his indebtedness for the first serious encouragement to pursue scientific studies. Dr. Buch had improvised a laboratory in his kitchen, where, on certain days, experiments were allowed. Among other things, aided by his young pupil, Dr. Buch analyzed some pyrites from Bohemia, in which he found the recently discovered element selenium, and published the result in Gilbert's "Annalen," to the great satisfaction of Wöhler, who then, for the first time, saw his name in print. The two also prepared some cadmium, another new metal, from zinc-ore.

Wöhler afterward carried with him on a pedestrian tour to Cassel and Göttingen a specimen of what he had prepared, in order to show it to its discoverer, Professor Stromeyer, and to have him identify it as genuine. It was during this visit that he made the acquaintance of the celebrated Blumenbach, whose text-book of "Natural History" he had zealously studied. Blumenbach received the young student very cordially, and kindly showed him the curiosities of his natural history collection. He could hardly have anticipated that a few years later the young man would become his colleague at the university, as the successor to the lamented Stromeyer.

By slow degrees Wöhler obtained more correct ideas of chemistry, and abandoned the doctrine of phlogiston, in which, without fairly comprehending it, he had at first believed. Dr. Buch's rich library was always open to him, and he was not, as formerly, confined to Hagen's old "Experimental Chemistry," which had been used as a text-book by his father. Chemical experiments now became a passion with him, they absorbed his mind by day and night; his room at home was transformed into a laboratory full of glasses, retorts, washing-bottles, and minerals—everything in the greatest confusion. No coal-hod in

the kitchen was safe in his sight, and it remains a wonder to the present day that he did not set the house on fire or poison some of the family by his operations in the kitchen! The breaking of a flask of chlorine at this period nearly suffocated him, and some severe burns by phosphorus suggested greater caution. He was particularly interested in experimenting with the voltaic battery, and succeeded in constructing one with one hundred small pairs of plates, with which he repeated Sir Humphry Davy's experiment of the isolation of potassium. All his efforts were now concentrated upon an attempt to prepare potassium in a chemical way, according to the method proposed by Curadeau. An old graphite crucible, which Bunsen, the director of the mint, gave to him, served as furnace, and, armed with a bellows loaned by the same person, the experiment was tried in the laundry, with his sister as assistant to blow the bellows. Great was his rejoicing when he perceived the balls of metal in the gun-barrel attached to the retort, and the sister was hardly less gratified at the result of their combined efforts. But the young chemist carried on other studies, to the detriment of his Latin and Greek. He constantly had instruction in drawing, to which his father, who himself drew well, attached much importance. He learned to draw from Nature, and his sketch-book always accompanied him on his excursions in the neighborhood and on the Rhine; he even tried painting in oil, and etching, for which he received much encouragement from the painter Morgenstern.

A rich present of antique Roman coins, which a friend of his father made him, increased his desire to collect similar ones to such a degree that he succeeded in getting together all of the coins of the Roman emperors in their order of succession; Roman urns, lamps, legion-stones, which at that time were still found in the ancient Roman encampments of the neighborhood, were also collected, and aroused in him much interest in Roman history. He likewise commenced to occupy himself with German literature, and to make himself acquainted with the poets of the last century, in which studies a young artist, his drawing master, was his guide. He was too young to appreciate the great political movements of the time, yet he always remembered with interest having seen Napoleon I. during his triumphal entry into Frankfort, and later the passage of the allied troops and Cossacks. His father bestowed particular care upon his son's physical development, and upon his strengthening of a naturally weak constitution by regular exercise, riding, fencing, swimming, and boating.

At Easter, 1820, when he had nearly completed his twentieth year, Wöhler graduated at the gymnasium and entered the university. Partly in accordance with his own inclination, and partly because favorable circumstances promised him success, it was decided that he should study medicine.

He spent his first year at the University of Marburg, where his father had also studied, and where many of his father's friends could

befriend and guide him. He attended the lectures on botany, zoölogy, mineralogy, physics, and anatomy, and began during the winter to perform dissections. But chemistry continued to be his favorite study, and, much to the disgust of his landlord, he transformed his parlor into a laboratory, and occupied himself with the study of sulphocyanic acid and cyanogen compounds in general. He discovered iodide of cyanogen, for to him at least it was a discovery, as he was not aware at the time that Davy had previously prepared it. In the joy of his heart he communicated the discovery to Wurzer, the Professor of Chemistry at Marburg, to whom it was also new, but, instead of receiving commendation, he was reprimanded for neglecting his medical studies to carry on original investigations. After spending one year at Marburg, Wöhler went to Heidelberg, filled with enthusiasm for Leopold Gmelin, who became his most cherished friend and master. He wished to attend Gmelin's lectures on chemistry, but was told by that professor that it was superfluous, and he accordingly abandoned the idea, and thus secured more time for work in Gmelin's laboratory and for intimate personal intercourse with this amiable and learned man.

Nearly all the time which his medical studies left him he devoted to chemistry, and even toward the close of his course, when practical medicine became very absorbing, he still continued to spend several hours daily in the laboratory. He resumed his researches on sulphocyanic acid at Heidelberg, and commenced those on cyanic acid, the results of which, at Gmelin's solicitation, were published in Gilbert's "Annalen." It was of great service to Wöhler at this time that Gmelin and Tiedemann were engaged upon their physiological researches, thus encouraging him to a similar line of study. He enjoyed to a high degree the esteem of Tiedemann, and owes to this excellent man the kind encouragement to pursue physiological researches, which proved so important in Wöhler's future career. Wöhler was one of the competitors for the prize offered by the medical faculty for a thesis on the "Migration of Matter into Urine," and had the good fortune to be successful. Among other things, it was shown by this research that plant-alkalies, in their transformation through the blood, are changed into carbonates. In September, 1823, Wöhler passed the university examination, and received the degree of Doctor of Medicine and Surgery, "*nec non artis obstetriciæ.*"

Immediately after leaving the University of Heidelberg it was Wöhler's intention to visit the larger hospitals of Europe, as a further preparation for the practice of his profession, but Gmelin advised him to abandon the uncertain practice of medicine and to devote himself solely to chemistry, for which specialty he had shown such decided inclination and talent. Acting upon this advice, Wöhler wrote to Berzelius for permission to study in the laboratory at Stockholm, and received from the great Swedish chemist the following answer: "Any

one who has studied chemistry under the direction of Leopold Gmelin has very little to learn from me; but, nevertheless, I can not forego the pleasure of making your personal acquaintance, and will therefore cheerfully accept you as the companion of my labors. You can come whenever it is agreeable to you." Armed with this permission, Wöhler at once made preparations for the journey. As his means were limited, he decided to take a sailing vessel from Lübeck, but when he reached that port he found that there was only a small craft in the harbor destined for Stockholm, and that it would be six weeks before she would sail. Of this delay he says, in a sketch furnished to the Berlin Chemical Society in 1875: "I could hardly have endured the loss of time had I not cultivated the acquaintance of Menge, the Icelandic traveler and genial mineral-dealer, in whose collections I could satisfy my fondness for minerals. I had already made his acquaintance in Frankfort, where I had exchanged specimens with him, and where he on one occasion introduced me to Goethe, who came to buy, a fine specimen of copper azurite from Chessy."

Menge introduced him to Kindt, the principal apothecary in Lübeck, for whom he formed a lasting friendship, and with whom he resided the last three weeks of his stay in town. To occupy his time while waiting for the ship to take in cargo, Wöhler undertook, in company with Kindt, to prepare some potassium according to the method proposed by Brunner. Instead of a wrought-iron retort, they made use of one of the bottles in which mercury is furnished to commerce, while a bent gun-barrel served as the neck of the retort. He obtained such a rich supply of potassium that he was able to take a large quantity to Sweden, which afterward proved of great importance in Berzelius's experiments on the isolation of silicium, boron, and zirconium. It was also in Lübeck that Wöhler met for the first time Mitscherlich, who was returning from a visit to Berzelius. At last the ship set her sails, and on the 23d of October, 1823, started for Travemünde, where he took passage on the 25th. After a very stormy passage the vessel dropped anchor at Dalarö, a small port situated on the rocky coast, whence, to avoid a long sea-voyage, he decided to go by land to Stockholm. The officer of the guard who examined his passport, on hearing that he was going to study with Berzelius, declined to accept the usual fee, saying he "had too much respect for science and his celebrated countryman to take money from one who, in the pursuit of knowledge, had undertaken so long a journey." Wöhler arrived at Stockholm at night, and early the next morning could hardly restrain his impatience to call upon the great master.

Berzelius had an official residence in the Academy of Sciences, and a medical student, whose acquaintance he had casually made, showed the way. We will let Wöhler himself describe his first interview: "With a throbbing heart I stood before Berzelius's door and rang the bell. A well-dressed, dignified gentleman, with florid and healthy

complexion, let me in. It was Berzelius himself. He welcomed me very cordially, informed me that he had been expecting me for some time, and wished me to tell him of my journey—all this in the German language, with which he was as familiar as with French and English. When he conducted me into his laboratory I felt as if I were in a daze, doubting whether I found myself in reality in these classic walls and in the fulfillment of all my dreams. He took me the first day to the institute, where he gave his lectures to medical students, but which were attended by officers of the army and several of his friends, and which I regularly visited afterward to accustom my ears to the language. This afforded me opportunity to admire his calm and clear delivery, and his skill in performing experiments. In this institute was also the laboratory for medical students, which was presided over by Mosander." The following day Wöhler at once set to work. He was provided with a platinum crucible, a balance with weights, and a wash-bottle, but had to furnish his own blowpipe, the use of which Berzelius strongly recommended. He was at that time the only pupil, as Mitscherlich, Henry and Gustavus Rose, had preceded him, and Magnus was his successor. The laboratory consisted of two common rooms, with very simple accommodations. There were neither furnaces, nor ventilators, nor water, nor gas. In one of the rooms were two pine tables, at one of which Berzelius had his place, while Wöhler worked at the other. There were the usual cases for reagents, a glass-blowing table, a water-trough, under which stood a pail, and where the cook Anna came every day to wash the soiled vessels. This cook was a famous character, and ruled over the establishment with despotic sway. As she was one day cleaning some vessels, she remarked that they smelt strongly of oxidized muriatic acid. "Look here, Anna," said Berzelius, "thou must not call it oxidized muriatic acid any longer, but chlorine—that is better."

Berzelius was at this time engaged upon his beautiful researches on hydrofluoric acid, silicium, boron, and zirconium. It was most instructive for Wöhler to follow these researches and note the methods pursued by the great Swedish chemist. After a hard day's work in the laboratory, Wöhler generally spent his long evenings in studying the Swedish language, and in translating Berzelius's treatises for Poggendorff's "Annalen." Sometimes Berzelius would retain him at his house, and entertain him with stories of Gay-Lussac, Thenard, Dulong, Wollaston, H. Davy, and other scientific celebrities, with all of whom he corresponded, and whose letters he preserved in separate portfolios. He permitted Wöhler to read his correspondence with these celebrated men, and also to peruse his journal of a visit to Paris and London. When the weather became more moderate and the days grew longer, Wöhler made short excursions to the mines, factories, and mineral deposits of the neighborhood of Stockholm, on some of which occasions he was accompanied by Berzelius. The first analysis which Berzelius

gave Wöhler to make was that of a new zeolite. In reality he performed the work himself, in order to show his method and all the manipulations peculiar to himself. "Afterward," says Wöhler, "he gave me a mineral called lievrite to analyze, which, as a test of my perseverance, I had to repeat till the results were uniform. If I had been hasty and the results did not agree, he would say, 'Doctor, that was quickly but badly done.'" Besides mineral analyses Wöhler prepared selenium and lithium, and repeated his experiments on hydrocyanic acid, which Berzelius had highly commended in his "Jahresbericht," and which he thought had contributed largely to establish the accuracy of the new chlorine theory. After the work in the laboratory ceased, Berzelius had promised Alexander Brongniart and his son Adolph, the botanist, to be their companion and guide on a geological journey through Sweden and Norway. Wöhler was invited to join this party, and gladly accepted the invitation. As the Brongniarts were not to arrive in Sweden before the middle of July, Wöhler improved the interval by making an extensive tour to a number of celebrated mines and quarries where he gathered a rich store of rare minerals to send to his German friends. He finally joined Berzelius at Skinskatteberg, the estate of Hisinger. The venerable and hospitable Hisinger, so well known for his contributions to the geology and mineralogy of Sweden, and also for the liberality with which he had supported Berzelius during the commencement of his studies, lived here, a very rich man, on a princely estate, surrounded by magnificent forests, gardens, and mines. The party spent a week here most delightfully, examining and testing minerals with the blowpipe and visiting mines. While they were waiting for the arrival of the Brongniarts, a traveler brought the news that Sir Humphry Davy was in Götheborg, and that he hoped to meet Berzelius before he left this part of the country. In the mean time the Brongniarts and Hans Christian Oersted arrived, but, being impatient, could not await the arrival of Davy, and continued their journey. Berzelius and Wöhler staid behind, and, in a few days, Davy's arrival was announced, and Berzelius at once waited upon him at his hotel. "The meeting of these two men," says Wöhler, "was very cordial"; and he adds, "Davy addressed some encouraging words to me when I was presented to him as a young chemist." Davy returned to England, while the rest of the party continued their journey to Norway. While at Christiania they encountered the Crown-Prince Oscar, then Viceroy of Norway, and, not being able to escape in time, were detected by the Prince, who stopped the procession, and called Berzelius to his carriage and asked him to dinner. Here was a dilemma; but Berzelius contrived to procure the necessary court costume, and to answer the summons to the royal presence.

This journey to Norway was one of the bright periods in Wöhler's history, and he always recalls it with pleasure to his pupils whenever

they ask him for the recital. Finally, in September, 1824, Wöhler took leave of Berzelius, and returned to the Continent. He stopped at Göttingen on his way to Frankfort, where he made the acquaintance of Hausmann, who subsequently became his much-valued friend and colleague. During a visit, which he immediately afterward made to Gmelin and Tiedemann, and in accordance with their advice, he decided to apply for the position of docent at the University of Heidelberg. While preparing to habilitate himself at the university, he enjoyed the intimate friendship of Dr. Buch and of the celebrated astronomer Sömmering, who was then much occupied with observations on the sun's spots, and with experiments on the concentration of alcohol through membranes. Wöhler undertook at this time the translation of Berzelius's "Jahresbericht," which Christian Gmelin, of Tübingen, Berzelius's first German pupil, transferred to him, as he himself could no longer continue it. Wöhler was the more willing to undertake this translation, as the sale of the book promised to defray by degrees the expense of his Swedish journey. It was while thus engaged at the University of Heidelberg, in 1824, that Wöhler first made the acquaintance of his life-long friend Justus von Liebig. The meeting of these two men took place at Frankfort. By a singular coincidence they had been working in the same direction on cyanogen compounds, and there was a slight scientific misunderstanding between them; but all this was at once dissipated when they met for personal explanation, and the two young men formed a friendship which continued unbroken to the time of Liebig's death. Finding that their ideas ran in parallel directions, instead of opposing each other, they decided to work together, and for many years they kept up frequent correspondence, met regularly for consultation, and spent their vacations together among the mountains. Liebig's hospitable home in Giessen and Munich became the headquarters for Wöhler, Buff, Kopp, and others, and here were subsequently planned many of the scientific researches which have so greatly enriched our chemical literature. When Liebig and Wöhler first met, the former was not twenty-one years of age, and the latter was only twenty-four; and yet both had become renowned already for their important discoveries. It is no disparagement to Liebig to say that the acquaintance with Wöhler was of inestimable value to him. The young man needed the quiet, thorough, and solid character of Wöhler to check his own too vivid imagination, and prevent him from jumping too hastily to conclusions. Liebig was quick and impulsive, Wöhler was slow and sure, and the two characters worked admirably together, the one supplementing the other. In after-years they were so much together that it would be difficult to say how far any investigation was absolutely original with either of them. They compared notes on all occasions, and it was especially Liebig who hesitated to publish until he had subjected his paper to the cool criticism of his friend. No envy and no jealousy

appear to have cast a shadow upon their friendship, and the large accumulation of letters in Wöhler's hands testifies to the tribute of respect and affection which Liebig showed toward one who could have been a most dangerous rival.

Wöhler's career took an unexpected turn during the winter of 1824–'25. The Gewerbeschule was at that time founded in Berlin. It consisted of but one class in the beginning, to which Henry Rose gave instruction in chemistry. Rose, Mitscherlich, and especially Leopold von Buch, recommended Wöhler for the chair of chemistry in the newly founded institution. To the two former he had been introduced by Berzelius, while Leopold von Buch had previously made his acquaintance while he was a student at the University of Marburg. The young student had made such an impression on Von Buch that he became his devoted friend and patron. Wöhler had found a new variety of harmotome (Phillipsite) in a basalt-quarry near Marburg, and, as Von Buch had in the last century published a notice of this mineral, the new variety greatly interested him, and he was also pleased to find a young man so well versed in mineralogy. When the question of the new position in Berlin was pending, Von Buch wrote a long and characteristic letter to Wöhler in which, with sprightly humor, he described the society and the chief personages of Berlin of that day, and endeavored to persuade the young chemist to select the Prussian capital, in preference to Heidelberg, as a place of residence. Wöhler did not long hesitate, and in March, 1825, removed to Berlin, where he was at once installed, under Director Kloeden, as teacher of chemistry and mineralogy. At first he only took the position on trial for a year, on a salary of three hundred dollars and a modest apartment. By degrees the institution grew in importance, and Wöhler's salary was very much increased, and a fine dwelling was assigned to him; and in 1828, by royal decree, he was raised to the rank of professor. It was at about this time that he was married to his first wife who was the daughter of a wealthy banker of Cassel. The young professor now entered upon a prosperous career. His residence at the capital of Prussia, the great resources which were at his command, the constant scientific intercourse with the favorite pupils of Berzelius, Mitscherlich, Henry Rose, Gustavus Rose, and particularly with his intimate friend Magnus, and the opportunity of meeting with other shining lights of the day, could not fail to exert an inspiring and instructive influence.

Wöhler always considered it peculiarly fortunate that he was here able to make the personal acquaintance of Alexander von Humboldt, and to have the privilege of listening to his intellectual conversations, and of attending his celebrated lectures on Cosmos. In the year 1828 Von Humboldt was made President of the German Association of Naturalists, and opened the session with a most finished and brilliant discourse, and, though crowded with work, he still found time during the meeting

of the Association to collect around him a choice circle of specialists, and in particular to show much attention to Berzelius, who was at that time on a visit to Berlin. Von Humboldt gave a breakfast in honor of Berzelius, which was remarkable for the number of celebrated men who were present at it. After the breakfast a drive was arranged to Humboldt's country-seat at Tegel. Here the host exhibited the art-treasures of his brother William, and afterward the whole party drove to the quarry of Rüdersdorf, where geology was discussed by the learned company. On this occasion, Wöhler has reported that it was very interesting to watch the contrast between Humboldt's well-known inexhaustible powers of conversation and Berzelius's quiet demeanor. Wöhler, being the youngest and slightest in stature, had a seat in a dog-cart between Humboldt and Berzelius. While on the way to the quarry, in the midst of one of Humboldt's harangues, Berzelius turned to Wöhler and said in Swedish: "O Lord, how this man does talk! I can't stand it much longer!" Wöhler was greatly embarrassed for fear that Humboldt would overhear the remark, but, as he kept on talking, this anxiety vanished.

This was, perhaps, the most prolific period of Wöhler's life, for at this time he published his famous researches on aluminum, glucinum, yttrium, and, in association with Liebig, on cyanogen, cyanic and uric acids. Gay-Lussac had proposed the question in the early part of the century whether, when cyanogen was treated with alkalies, a cyanic acid might not be produced, and it was in answer to this question that Wöhler published his first paper in Gilbert's "Annalen" in the year 1822. It was at the same time that Liebig, then a boy in years, had gone to Paris to show Gay-Lussac what he had done in the same direction; and it was Humboldt who aided the boy chemist in Paris, just as he did Wöhler in Berlin in later years. Subsequently, as we have seen, Wöhler and Liebig made common cause of this investigation, and published their researches together. But the most important research of Wöhler falls in the year 1828.

This was the artificial production of urea. This investigation forms an epoch in the history of chemistry. Previous to this time the so-called organic world and the functions of vital force were believed to constitute a realm by themselves. Berzelius had said distinctly in his great text-book that we should never be able to imitate the products of vital force in our laboratories. We could destroy and could build up material things, but to imitate the vital forces would always be impossible. Wöhler, at the age of twenty-eight, overthrew this theory and created a revolution in the domain of chemistry. He made a breach through what appeared to be an impenetrable wall, and this opening has gone on increasing ever since, until it would appear as if, in a few years, no wall would be left standing. Berzelius's estimate of the value of the research on artificial urea is given in a most genial letter which he wrote to Wöhler in January, 1831, and which

has recently been published in Germany. Wöhler had found in a mineral what appeared to him to be the oxide of an unknown metal, and he sent a specimen of the strange substance to Berzelius with an interrogation-mark. The new substance proved to be oxide of vanadium, and the fact that Wöhler narrowly escaped discovering it led Berzelius to write the following letter, which we translate entire:

STOCKHOLM, *January* 22, 1831.

. . . . In reference to the specimen sent by you, designated with an interrogation-mark, I will relate the following story: In the remote regions of the north there dwells the goddess Vanadis, beautiful and lovely. One day there was a knock at her door. The goddess was weary, and thought she would wait to see if the knock would be repeated, but there was no repetition, and whoever it was went away. The goddess, curious to see who it could be to whom it appeared to be a matter of so much indifference whether he was admitted or not, ran to the window to look at the retreating figure. "Ah!" said she to herself, "it is that fellow Wöhler; he deserves his fate for the indifference he showed about coming in." A short time afterward there was another knock at the door, but this time so persistent and energetic that the goddess went herself to open it. It was Sefström who appeared at the threshold, and thus it was that he discovered vanadium. Your specimen is, in fact, oxide of vanadium. But the chemist who has invented a way for the artificial production of an organic body can well afford to forego all claims to the discovery of a new metal, for it would be possible to discover ten unknown elements without the expenditure of so much genius as appertains to the masterly work which you, in association with Liebig, have accomplished and have just communicated to the scientific world.—JOHAN JAKOB BERZELIUS.

Notwithstanding the great advantages which his position offered in Berlin, and the favorable prospects open to him in the future, Wöhler was constrained, for domestic reasons, to resign his professorship in 1832, and to remove to Cassel, where his wife's family resided. For several years he held no official position, and occupied himself with the translation of the third edition of Berzelius's text-book of chemistry, and with the yearly reports. He spent some time with Liebig, at Giessen, where the two friends completed their important research on the oil of bitter almonds. The large supply of arsenical nickel which had accumulated as an incidental product at the prussian-blue factory in Cassel led Wöhler to invent a method by which the nickel could be economically separated, to be subsequently used in the manufacture of German silver. The process succeeded so well that extensive nickel-works were established, yielding many thousand pounds for exportation to Birmingham. He, at that time, proposed nickel as a suitable metal for coinage, but no attention was paid to the suggestion. While Wöhler was residing at Cassel, a Gewerbeschule, similar to the one in Berlin, was founded, and he was appointed to a position corresponding to the one he had held in Berlin, and was one of the three officials upon whom devolved the organization of the new institution. Afterward Professors Buff and Phillips were added to the corps of teachers.

Wöhler's duties as professor at the Gewerbeschule naturally directed his attention to technical chemistry, and in the autumn of 1833, in company with his intimate friend Magnus, he made a journey to France and England, to visit laboratories and chemical works, and on this tour had the opportunity to become personally acquainted with the most eminent living scientists of that period. In March, 1836, Professor Stromeyer having died the previous year, Wöhler was called to Göttingen as Professor of Chemistry and Pharmacy, Director of the Laboratories, and Inspector-General of all the Apothecaries of the Kingdom of Hanover. His place in Cassel was supplied by Professor Robert Bunsen, who previous to that time had been a docent at Göttingen, and at the present time is the renowned teacher at the University of Heidelberg. Wöhler could not at first refuse the post of Director of the State Apothecaries, and for twelve years traveled over the kingdom at great inconvenience and loss of time; he finally resigned this branch of the service, and gained more time for research. He has been seven times elected Dean of the Medical Faculty, until he declined a further nomination.

In 1860 Wöhler was made permanent Secretary of the Royal Hanoverian Academy of Sciences, to succeed Hausmann, and this position he continues to hold at the present time, attending to all the duties of correspondence with the punctuality of a young man, recalling his intimate friend Dumas, who at the same age holds a similar post in the French Institute.

In 1873 the fiftieth anniversary of Wöhler's doctorate was celebrated with great pomp by the students of the university, and on the 31st of July, 1875, being the fiftieth year of his active career as a teacher, and the seventy-fifth of his age, addresses and congratulations were poured in upon him from all parts of the world. During the current year, on the occasion of the eightieth anniversary of Wöhler's birth, the demonstrations of honor and rejoicing will be general at all of the seats of learning in Europe and America, and a presentation of a gold medal will be made to him to commemorate the interesting event. In the course of a long and distinguished career, the universities, learned societies, and sovereigns of Europe have vied with each other in conferring honors upon Wöhler. He received the Order of Merit from Prussia, the highest title of dignity from Hanover, and was elected one of the eight foreign associates of the French Institute, and the Emperor Napoleon made him an officer of the Legion of Honor; and so many decorations and diplomas have been presented to him that the mere catalogue would fill a page. The principal published works of Wöhler have been his translations of Berzelius's "Yearly Reports," and Berzelius's "Text-book of Chemistry"; also "Grundriss der Unorganischen Chemie und der Organischen Chemie"; "Mineral Analyse mit Beispielen," etc. These books have passed through numerous editions, and latterly the "Organic Chemistry" has been edited by Pro-

fessor Fittig, formerly Wöhler's assistant at Göttingen. During the last fifty years Wöhler has published in Gilbert's, Poggendorff's, and Liebig's "Annalen" more than two hundred and fifty different papers on chemical subjects, or an average of five every year. Although these contributions have been of great importance to the progress of the science, the crowning glory of Wöhler must be sought in the influence he has exerted as a teacher of chemistry. During the last forty-four years his laboratory at Göttingen has been the workshop in which great numbers of students have been taught how to conduct original researches, and many of these pupils have become professors all over the world. All of those who took their degrees must have presented an original thesis; and in nearly every instance, although the student performed the physical labors of the research, the suggestion, the topic, and the method came from Wöhler. It is difficult to measure the importance of such a life, or to express in fitting terms the gratitude we owe the man. All who have had the privilege of nearer relations to him have learned to love him as a man, revere him as a teacher, and respect him for the profundity of his knowledge.

Professor Wöhler has been twice married. His first wife died many years ago, leaving a son and daughter. His only son now resides near Göttingen, and is a wealthy landed proprietor; the daughter by the first marriage is the wife of the Burgomeister of Göttingen, and has children and grandchildren, so that Wöhler lives to see several great-grandchildren gather at his family board. By his marriage to the wife who still survives there have been three daughters, all living, two of whom are married, one residing in Hamburg and the other in London. The venerable man is surrounded by family and friends, with an ample fortune to provide for every want. He has ceased to deliver lectures or to impart instruction in the laboratory, but maintains the liveliest interest in all questions of the day, and in his private correspondence displays the vigor and playfulness of his youth.

CORRESPONDENCE.

OBSERVATION OF THE ENGLISH SPARROW.

Messrs. Editors.

AS the habits and value of the English sparrow are now being investigated in various parts of the country, I submit the results of my own observations made during the last three or four years, or since the bird became abundant in this locality. The charge frequently made, that the English sparrow drives our native birds from their accustomed haunts, does not apply to this vicinity. The sparrows are very numerous, are noisy and sometimes aggressive in their habits, but appear to quarrel much more among themselves than with other species of birds. I have not noticed any superior combative power which would enable them to do that which they are charged with doing. They are with us during the year—about our grounds and dwellings in great numbers. They are companions of the song-sparrow, snow-bird, woodpecker, chickadee, creeper, nuthatch, etc. There is no conflict or dispute among them. During the inclement weather of winter I feed the birds frequently, sometimes daily, and have watched their movements with great interest. I have not seen a dispute in their efforts to obtain the coveted food. The woodpeckers and chickadees gathered the bits of meat, the fringilla the seeds, which I scattered.

Nor have I noticed any considerable controversy at the nesting-season. Bluebirds are the first to arrive, and sometimes find their former nesting-places occupied by sparrows, but no disturbance occurs, the bluebirds finding other places for their nests. I have several times noticed, however, that the bluebirds are masters of the situation when a struggle takes place for an empty box. At this writing, bluebirds, sparrows, orioles, and many other species have their nests on my grounds, and equally so on the grounds of others in our neighborhood. I have no doubt there are fifty birds'-nests within a short distance of my dwelling. Robins, blackbirds, cat-birds, orioles, warblers, finches, and fly-catchers of many kinds are all about us, very much more numerous than they were in our boyhood.

All birds of species which love the shade of the woodlands are of course undisturbed by sparrows, which seek open spaces near dwellings, not the forests. Nor will it be claimed that larger birds, such as the robin, suffer from the presence of the sparrows. With us the barn-swallow is among the most peaceful and unobtrusive of birds, and yet it does not seem to be in any great fear of the sparrows, as the following incident will show: A pair of swallows commenced building a nest under a shed on my premises, but a sparrow was soon seen sitting on the side of the half-finished structure. Directly the swallows commenced building another nest within a few feet of the first, and no further disturbance took place. The nest was finished and occupied by the swallows. Sparrows have not driven our native birds away, neither have they given cause for any serious complaint on account of destroying our grain, as they seem to have done in some other places. I think, in this particular, it would be well for people to observe carefully for themselves. In winter, indeed, at all seasons, sparrows delight to feed on half-digested grains thrown from stables, or scattered elsewhere, but in spring and summer I have seen them carrying animal food to their broods. This they do persistently and in large quantities, the supply consisting largely of insects, larvæ, worms, etc. I have seen them catch insects on the wing as do the fly-catchers.

I have not observed that they eat berries, grapes, or other small fruits, but have seen them picking the soft grains of sweet-corn. If their food were scanty or unsuitable, it is probable that they would feed more freely on the valuable grains. The birds which do most damage to farmers in this vicinity are blackbirds, robins, cat-birds, and a few other species, which feed on cherries, blackberries, grapes, and similar fruits. When the fruits are ripe, the trees and bushes swarm with these birds, but we hear of no prejudice against them on that account, while the sparrows are freely condemned for like offenses.

Respectfully, JOHN D. HICKS.

OLD WESTBURY, LONG ISLAND, *5th Mo. 18th*, 1880.

AN EXPLANATION.

Messrs. Editors.

THE author of the article in "The Popular Science Monthly" of the present month, with the caption "The Classics that educate us," it is probable has not seen President Eliot's interpretation of the passage quoted from the address made at Smith College in 1879. The friends of the higher education

looked upon it as an extraordinary statement, and in one of our journals the following criticism appeared: "Will President Eliot offer the public some fuller explanation of his meaning? What training to the powers of observation is given by the study of the mother-tongue? What training to the art-faculties? What to the knowledge of abstract truths? What to the faculties which deal with abstract truths? What to the power of reasoning? Does President Eliot mean that an acquaintance with the mother-tongue trains every faculty which is trained by mathematics, science, metaphysics, and æsthetics—or does he mean that the training of these faculties is not essential to a good education—that education may be partial and yet adequate?"

The statement, President Eliot afterward remarked, "can easily be misunderstood," and was misunderstood, and is still used to prove something that he did not design it should be used to prove. There can be no dispute as to the correctness of the remark that "an accurate and refined use of the mother-tongue is an essential part of the education of a lady or gentleman." No one would consider an education complete without this part of it. A violation of the rules of grammar in speaking or writing the mother-tongue would at once show an imperfect education.

The Rev. Lyman Abbott published Mr. Eliot's explanation. In an article in the "Christian Union" Mr. Abbott remarked: "Our readers may remember an editorial paragraph calling attention to a reported utterance of President Eliot, of Harvard College, on the subject of education. We, at the same time, addressed him a private note, to which we have received the following reply":

"HARVARD COLLEGE, CAMBRIDGE, MASS., *July* 26, 1879.

"MY DEAR SIR: Your obliging note of July 3d arrived just after I had left Cambridge for a yacht-cruise on the Maine coast. Hence the long delay of this reply.

"I do not feel inclined, in these blessed vacation-days, to write even the shortest article—not even to justify a statement of mine which, it seems, can easily be misunderstood. I did not say that a study of the mother-tongue supplied a complete mental training; but only that no one was a gentleman or a lady who had not a refined and accurate use of the mother-tongue. That attainment I find essential to my conception of a gentleman or a lady. A gentleman or a lady will have other mental acquisitions; but these will not be essential, as that is. To illustrate: salt is an indispensable article of diet; one may, further, eat bread, or beef, or oatmeal, but salt one must have, whatever the other articles consumed may be. Moreover, neither bread, nor beef, nor oatmeal, is indispensable in the same sense.

"But, as you suggest, the remark quoted and questioned in your paper was incidental; and I am quite willing that it should go for what it was momentarily worth.

"Very truly yours,

"CHARLES W. ELIOT.

"REV. LYMAN ABBOTT."

We can accept President Eliot's explanation that, as salt is necessary in all our food, so the mother-tongue should appear in its refined and accurate use in all our studies—rather than suppose an incidental remark should be used against the study of the classics. It would be singular, indeed, if the president of a great university should be placed in opposition to the study of subjects which are assigned so large a place in its curriculum as the ancient languages; rather would it be supposed that he would say with Dr. Seelye, of Smith College: "The relation, however, of the classics and mathematics to intellectual growth, if correctly apprehended, rests on unalterable facts in the history of man and the constitution of nature. They are to be studied, not because the college demands them, but because they are an essential condition to the broadest mental culture. Unless they are early taught, the chances are they will never be acquired. Those who wish to pursue a higher education will find themselves embarrassed every step forward without them."

It is evident that the remark of President Eliot was thrown off parenthetically in the address before the young ladies of Smith College, and was never intended to be used as it has been by writers and speakers on the subject of classical studies since the day it was uttered.

We think it is due to classical study and its friends that this explanation should be made in your widely-read "Monthly."

Yours, truly,

TRAILL GREEN.

EASTON, PENNSYLVANIA, *June* 9, 1880.

A SHOWER OF DUST.

Messrs. Editors.

FROM two to five o'clock on the morning of March 28, 1880, we had a storm of wind and rain in this part of Indiana. After daylight a remarkable deposit of brown or slate-colored dust was found to have fallen on porticoes, flat roofs, etc. It was also observed, in places, on the earth's surface. The phenomenon was noticed by our citizens generally, and it was spoken of in some of our papers. Professors Wylie and Newkirk, as well as myself, collected quantities of the dust. Some

freshly painted buildings retained the marks of the shower for several weeks. The deposit was noticed at places more than fifty miles distant. Mr. J. W. Hollingsworth, of Paoli, Orange County, Indiana, informed me that the fall there was very abundant. I intended at the time to write some account of the remarkable shower, but being then busy I neglected it. My attention was recalled to the matter by an account in "Nature" (April 15th), of a similar shower about the same date, on the opposite hemisphere. Dr. Thomas C. Van Nuys, Professor of Chemistry in the State University, has kindly furnished me the following partial analysis:

Silica, SiO_2, 64·95 per cent.; ferric oxide, Fe_2O_3, 5·39 per cent.; alumina, Al_2O_3, 10·20 per cent.; calcium oxide, CaO, 1·53 per cent.

Yours very truly,

DANIEL KIRKWOOD.

BLOOMINGTON, INDIANA, *June* 24, 1880.

EDITOR'S TABLE.

WILKIE COLLINS ON INTERNATIONAL COPYRIGHT.

WE can not congratulate the English on the treatment of the international copyright question by some of their eminent authors. It was but the other day that we had to point out the lack of good sense exhibited by Matthew Arnold in his very complacent discussion of the subject; and now comes a blast from Wilkie Collins which, although it does not amount to much, is still a perverse and unhelpful utterance. The reputations these men have are certainly not justified by their outgivings in relation to this important measure.

Mr. Collins writes for the "International Review," and is very indignant at the American "thieves" and "pirates" by whom he is "robbed." He seems to think that the main thing now is to brand these rascals indelibly; and so, to insure the full effect of his reproaches, he stipulates with the editors that not a denunciatory word shall be omitted from his paper; and they declare in a note that the said words are every one there, while "they must disclaim all responsibility for the language adopted by him in his argument."

Considerably more is made of this point than it is worth. There is obviously nothing new about it, as excoriating adjectives have been abundantly applied to us before by suffering authors. Nor is there anything objectionable in it; on the contrary, we are glad to see Mr. Collins "call a spade a spade," and mete out to those who steal his books the reprobation they deserve. Strong words are needed to characterize gross wrongs, and we agree that this is a case that calls for them. Mr. Collins is right in venting his righteous indignation in the most telling terms he can command: we only regret that he has been unable to give some freshness and new pungency to his invective.

But, when Mr. Collins gets through with his feeble vituperation, and comes to the practical question of what is to be done, he is then far less satisfactory. As a scold he is commonplace enough, but as a guide to lead us out of difficulty he is without qualification. To his diatribe we say "amen"; to his reasoning we say, "it won't do." He here betrays lack of judgment, and shows himself to be impracticable. We agree with him that there is a palpable and vicious wrong to be set right; but the question is, how to accomplish it. The wrong requires to be defined and limited, that we may know precisely who suffers by it, and what must be the nature and extent of the remedy. The wrong here is, that the American Government does not protect the rights of foreign authors to property in their books; and, as that property is unprotected, it is appropriated by anybody who chooses to take it. Mr. Collins has an undoubted right to be thus protected, and, if he

were a discreet man, he would confine his claim to its impregnable ground, and force his case in the direction where no resistance can be offered. But he stretches his claim until he destroys it, as may be easily pointed out.

The ideas and language, the soul and essence of a book—that which properly *creates* it—are contributed by the mind of the author. It is work, the product of toil and skill and time and capital, just as much as any other construction of industry. All civilized countries recognize and guard the right to this kind of property. We do it in this country in the case of our native authors, thus abundantly vindicating the theory and the practice. But we have the illiberality, the narrowness, and the meanness, to refuse this act of justice to foreign authors simply as foreigners. And for this course there can not be conjured up even a decent pretext; we simply want the works of these foreign authors, and outlaw them for the benefit of whomsoever can make money out of their productions. It is the duty of Mr. Collins and all others who are victims of this policy to protest against it as an outrage; and he should demand that his rights be admitted and his property defended by the authority of American law. Here his position is invincible.

Nevertheless, the case is not without its difficulties as viewed in the light of experience. There is no nation that recognizes an author's right in his book as absolute, indefeasible, and perpetual, like the rights to other kinds of property. Book-rights, like patent-rights, are limited, and expire in all countries after the lapse of specified though variable periods. Mr. Collins can not own his book for ever, even in England. It may be that this is unjust; but the demands of ideal equity are nowhere met. As a matter of fact, men have to be content with proximate justice; and the foreign author pushes his claim as far as is wise or expedient or practical, when he demands that the United States shall place him upon an equal footing with American authors as regards protection. Should he require that our Government guarantee his literary rights as interminable, he would so encumber his valid claim that it would be futile to urge it. We simply mean by this, that Mr. Collins has got to take circumstances into account if he proposes to attain a practicable end.

The book-manufacturer is his partner in business, whose office is to take the author's literary creation and give it a material embodiment for public use. The business partner makes copies of the work, publishes it, and manages the sales. He generally furnishes the capital required to produce the desired editions. He pays for the labor of typesetting, for paper, printing, and binding, and when the books are sold he gives the author a stipulated part of the returns. But there is this difference between the parts of a book contributed by the author and by the publisher, that while the author's portion is protected by public law in a qualified way or not protected at all, on the other hand the part contributed by the publisher is protected always and everywhere, and as absolutely as any form of property is ever protected. The American Government will not protect Mr. Collins's right of property in his book, but in every court in the land it will protect the rights of the man who pirates it. The publisher may steal the author's part, but no man may steal the publisher's part without incurring all the penalties of theft. Publishers, therefore, as such, are in need of no protection; they are everywhere abundantly cared for.

Yet it is a great thing for the publisher to get the advantage of that monopoly in the commerce of a book which the author's copyright confers. When he secures this advantage, he can put whatever price he pleases upon the stock which he has worked up into a

book. The materials and labor used have their fixed price in the market; but, when the book is produced, the publisher arbitrarily determines what it shall sell for. He is at liberty to fix the scale of his own profits, and as a business man he will always do it with sole reference to his own interest. Various considerations may influence his decision; but the most important fact is, that the copyrighted book will encounter no competition in the market. For these reasons it is of the greatest moment to publishers to make such arrangement with authors as will secure them the large possible benefits of copyright. If the author's interest in a book is represented by ten per cent., than the publisher's interest is represented by ninety per cent.; that is, the publisher is nine times more concerned to get this advantage than the author. Hence the strong desire of foreign publishers to get into the American market under cover of their authors' rights.

Now, Mr. Collins comes over here as the virtual agent and attorney of his English publishers. He first makes an outcry about the violation of his rights as an author in this country, and then he includes as one of these rights the liberty of carrying his publisher with him wherever he pleases. He will only be satisfied with an international copyright law in which this is conceded. But he here asks for a privilege, a convenience, a very profitable condition to his friends, and not for a guarantee of justice to himself. Mr. Collins has rights which ought to be regarded and defended in this country by international arrangements; his English publisher has no such rights, nor can he claim on any principle of justice that our Government should so shape its conventions that he can supply our market, if he pleases, with only English editions of his books. If there were no other way for the Americans to obtain his works, it might be different. Mr. Collins might well demand that there be no impediment to the supply of his publications that would hinder his realizing the full benefit of American sales. But, so long as there are plenty of publishers in this country eager to make contracts with him, it is no wrong—not even a hardship—for him to get what he rightfully asks, on the condition that his books shall be published here.

Mr. Collins unwittingly concedes the case when he undertakes to define his claim. He says: "The object of international copyright is to give me by law (on conditions with which it is reasonably possible for me to comply) the same right of control over my property and my book in a foreign country which the law gives me in my own country. In Europe this is exactly what we have done. When I publish my book in London, I enter it at Stationers' Hall and register it as my property — and my book is mine in Great Britain. When I publish my book in Paris, I register it by the performance of similar formalities—and again my book is mine in France. In both cases my publisher (English or French) is chosen at my own free will." But the same right of control over his property in his book in a foreign country that the law gives him in his own country is exactly what it is now proposed that he should have. His native protection stops with the British Islands and hardly extends to the provinces; his French protection is bounded by the limits of France; and his protection here would be coextensive with our nationality. What more, then, can he ask than an international copyright treaty that shall enable him to register his book in Washington, by which it becomes his American property, with the liberty of playing his free-will from the Atlantic to the Pacific in the choice of a publisher?

Nearly fifty English authors of the highest character have recognized that their rights of property in their books in this country should not be complicated with the interests of their home

publishers. They thus simplify the matter completely, and present to the American people the naked issue, Will you pay for what you appropriate? Will you protect our property rights as you protect those of your own authors? Will you render us the justice to which we are entitled by the moral judgment of the civilized world? Mr. Collins wants far more; but, if he has the slightest idea of getting it, we advise him to possess his soul in great patience and abstain from futile flurries, for he will assuredly have to wait a long time before he gets what he wants.

POLITICS AGAINST POLITICAL SCIENCE.

It is needless to call attention to Mr. George's vigorous and impressive article which opens this number of the "Monthly," on "The Kearney Agitation in California," as illustrative of the working of American political and social institutions. The name of the writer and the interest of the topic will cause his contribution to be carefully read. Mr. George closes by invoking the scientific spirit and the scientific method in the study of these phenomena, which he thinks demands the serious attention of the most thoughtful men.

This appeal is legitimate, and is prompted by the inevitable logic of the situation. There must be a far better general understanding of the working of social forces before anything can be hoped from remedial measures; but we are here confronted at the outset with difficulties of a very formidable character. One of the chief of these is that the spirit of our politics is radically anti-scientific. It is essentially hostile to science because it cultivates systematic misrepresentation, while the first requirement of science is allegiance to truth. Science begins with morality. It implies rectitude of thought, exemption from prejudice and passion, and the utmost attainable accuracy in its representations. It is a school—the only school we have—for discipline in truthfulness. Partisan politics, on the contrary—and partisanship is the essence of politics—is a school of deception and falsehood, and all its influences are at war with the fundamental virtue of truthfulness. If it be thought we are going too far in saying that our political institutions educate the people to immorality, we appeal to the highest authority on moral subjects which our country has produced.

More than forty years ago Dr. William Ellery Channing gave a lecture in Boston on the subject of self-culture. In speaking of the means of self-improvement open to the people of this nation he refers to politics, or to the influence of our popular institutions in arousing the mental activity of citizens which thereby becomes a means of general self-education. But, having turned the customary patriotic compliment to this beneficent action of our form of government, Dr. Channing pauses, as if conscious that he had gone too far, and then proceeds in a very different strain to acknowledge that, as a matter of fact, no such benign result is gained. He declares, on the contrary, that the influence of politics is to produce a widespread demoralization by a subversion of all the cardinal virtues of character. He says:

> It may be said that I am describing what free institutions ought to do for the character of the individual, not their natural effects; and the objection, I must own, is too true. Our institutions do not cultivate us, as they might and should; and the chief cause of the failure is plain. It is the strength of party spirit; and so blighting is its influence, so fatal to self-culture, that I feel myself bound to warn every man against it who has any desire of improvement. I do not tell you it will destroy your country. It wages a worse war against yourselves. Truth, justice, candor, fair-dealing, sound judgment, self-control, and kind affections, are its natural and perpetual prey.
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> I do not say that you must take no side in politics. The parties which prevail around you differ in character, principles, and spirit, though far less than the exaggeration of pas-

sion affirms; and, as far as conscience allows, a man should support that which he thinks best. In one respect, however, all parties agree. They all foster that pestilent spirit which I now condemn. In all of them party spirit rages. Associate men together for a common cause, be it good or bad, and array against them a body resolutely pledged to an opposite interest, and a new passion, quite distinct from the original sentiment which brought them together, a fierce, fiery zeal, consisting chiefly of aversion to those who differ from them, is roused within them into fearful activity. Human nature seems incapable of a stronger, more unrelenting passion. It is hard enough for an individual, when contending all alone for an interest or an opinion, to keep down his pride, willfulness, love of victory, anger, and other personal feelings. But let him join a multitude in the same warfare, and, without singular self-control, he receives into his single breast the vehemence, obstinacy, and vindictiveness of all. The triumph of his party becomes immeasurably dearer to him than the principle, true or false, which was the original ground of division. The conflict becomes a struggle, not for principle, but for power, for victory; and the desperateness, the wickedness, of such struggles, is the great burden of history. In truth, it matters little what men divide about, whether it be a foot of land or precedence in a procession. Let them but begin to fight for it, and self-will, ill-will, the rage for victory, the dread of mortification and defeat, make the trifle as weighty as a matter of life and death. The Greek or Eastern Empire was shaken to its foundation by parties which differed only about the merits of charioteers at the amphitheatre. Party spirit is singularly hostile to moral independence. A man, in proportion as he drinks into it, sees, hears, judges by the senses and understandings of his party. He surrenders the freedom of a man, the right of using and speaking his own mind, and echoes the applauses or maledictions with which the leaders or passionate partisans see fit that the country should ring. On all points parties are to be distrusted; but on no one so much as on the character of opponents. These, if you may trust what you hear, are always men without principle and truth, devoured by selfishness, and thirsting for their own elevation, though on their country's ruin. When I was young, I was accustomed to hear pronounced with abhorrence—almost with execration—the names of men who are now hailed by their former foes as the champions of grand principles, and as worthy of the highest public trusts.

This is a dark indictment, but Dr. Channing was a man who weighed his words. He represents partisan politics as a blighting influence, fatal to self-improvement, hostile to moral independence, and degrading to character. He says that "truth, justice, candor, fair-dealing, sound judgment, self-control, and kind affections, are its natural and perpetual prey." A system the spirit of which makes "truth" its "natural and perpetual prey," it is needless to say, is not favorable to science. Science can not grow, it can not exist, in such an atmosphere.

If it be said that Dr. Channing wrote forty years ago, the reply is that forty years have not mended matters. There is, on the contrary, every evidence that party ends are now pursued in this country with more recklessness of falsehood and more shameless unscrupulousness than ever before. That "all is fair in politics"—a maxim that would be scouted in the cock-pit and on the race-course—is not a recent rule; but the bad arts of an inveterate partisanship have been gradually perfected. With our political progress principles are progressively eliminated from politics, and first-class men are driven from the field. More and more it is becoming the function of the people merely to ratify at the polls the proceedings of wire-pullers, plotters, intriguing demagogues, caucus-bullies, and convention-desperadoes. It is notorious that our politics has passed into the hands of practiced professionals, who outmanœuvre straightforward men, and drive them to the wall. Everything is done by management and under false pretenses. Party excitement is stimulated by stirring up the meanest passions and by plying all the arts of detraction and falsehood. When the campaign opens, the sluices of slander soon run full. Here comes the last "Evening Post," representing the state of things in 1880. In a leader it says: "As generally conducted, our Presidential campaigns are so volcanic out-

bursts of passion and prejudice, and are accompanied by such torrents of vulgar calumny, falsehood, and abuse, that they are anything but creditable to our self-respect and tastes. They not only let loose every viler form of uncharitableness and evil-speaking, but they are permitted to absorb the energies of society to such an extent that even commercial activity is arrested, and the best moral and social developments are paralyzed for the time. In these quadrennial saturnalia the participants, for the most part, take leave of their senses, and comport themselves like bedlamites or Mænads." In the national campaign preceding the last, one of the candidates, as we all remember, was constrained to say, "I hardly know whether I am running for the Presidency or the penitentiary." In the last campaign a Presidential candidate received the suffrages of a majority of the people of the United States, but he failed to get the office, and has ever since been hunted with libels and blackened with calumny, until multitudes regard him as a consummate knave, fit only for the State-prison.

In these vile practices of falsehood and detraction the whole country is implicated, for we are a nation of politicians. Politics is not only the dominant subject of thought, but its method is the dominant method of thinking. We have hundreds of colleges and thousands of common schools, multitudinous newspapers and countless pulpits, and all, as we say, for the promotion of public intelligence and the elevation of public morality; but, when election comes, professors, teachers, editors, and clergymen, all join in "saving their country" by the means which Dr. Channing has so fittingly characterized. Whoever is in the pulpit, the pews are filled with politicians; whoever is editor, the subscribers are politicians; all the instructors in our public schools are political stipendiaries, and politicians dictate the studies. Indeed, the reason given for the very existence of these schools is political. As for the colleges, they are more than anything else workshops for the manufacture of politicians; as was sufficiently attested by President Hayes, the other day, when he told them at Yale that the great office-holders are mere figure-heads shaped by the institutions where office-holders are made.

So rooted and so fortified is this political system which perpetually preys upon truth and justice, corrupts the morals of the nation, and flames out in Kearneyism and kindred scandals of a reckless partisanship which disgrace every State in the Union. But, powerfully intrenched as it is, we believe that this system is destined to be ultimately improved if not renovated. But it will be slow work, and the reform will not proceed from within. Politicians engendered by the system will not transform it. The amending and elevating influences must come from without. Men must be thoroughly freed from the system before they can deal with it efficiently. The first thing needed by the American citizen is to gain an independent position for the critical study of the institutions of his country; and this can only be done by vigorous individual revolt against party domination. The powerful spell of partisan influence must be broken before men can be qualified to pursue the study of politics by the scientific method, for under the bias of party feeling nothing is seen aright. Personal independence of action in political matters, freedom from the trammels of partisanship, is the true preparation for the intelligent investigation of political questions. Multitudes of our best people are already thoroughly disgusted with politics. Thousands will not go to the polls except under pressure of violent campaign excitement. Politicians denounce this as unpatriotic; but there can be no duty to one's country so imperative as rebellion against party

machinations and behests. In this growth of Protestantism against the immoral tyranny of the old political church is our hope. Mr. George rightly appeals to the spirit and method of science, applied to political and social affairs, as the great agency of national redemption, and time will show that the appeal is well taken. The great love of intellectual advancement is bound in time to give us a science of politics grounded in principles of truth, instead of the quackish arts of partisanship, just as certainly as it has given us a science of navigation, agriculture, and chemical manufactures.

LITERARY NOTICES.

SPENCER'S "EDUCATION." CHEAP EDITION.

EDUCATION: INTELLECTUAL, MORAL, AND PHYSICAL. By HERBERT SPENCER. New York: D. Appleton & Co. Pp. 283. Price, 50 cents, paper covers.

THIS little work has now been twenty years before the public, and during that time has gradually made its way to all parts of the civilized world. It has been rendered into the principal languages of Europe, and is well known by complete or partial reproduction in India, China, and Japan. The eminent directors of public education in different countries have taken the initiative in procuring its translation.* The principles it develops have been avowedly followed in numerous instances in shaping the policy of public instruction, and in organizing educational institutions; and it has exerted a strong influence upon the mental and moral culture of families, and upon the intellectual life of individuals. Desirous of still further extending an influence so well approved, Mr. Spencer a year or two ago issued a cheap edition of the book in England, and the American publishers have now wisely imitated his example.

We do not propose here to notice the book in the usual manner, as most of our readers are no doubt quite familiar with its contents. But this is a suitable occasion to recall the circumstances of its origin; and the more so as thereby some explanation will be afforded of its remarkable influence and success.

The four parts which compose the volume were originally contributed by Mr. Spencer to several English periodicals from 1854 to 1859. The period in which they were written, 1850 to 1860—from his thirtieth to his fortieth year—was the most fruitful in his intellectual career, and may be characterized as preëminently the creative and constructive decade of his life. It was the time of the rapid development and organization of his great ideas. It was then that he arrived at the conception of evolution as a universal law and the basis of a new philosophy; and that he drew up a detailed plan of the reorganization of knowledge from the new point of view. The period referred to was one of transition, or rather of *maturing*, for from early years the subject of progress and development in nature and society had taken a strong hold of Mr. Spencer's mind. All his publications during these ten years are colored and pervaded by the dominant conception of evolution. His work took a wide range, chiefly in the form of elaborate articles printed in leading periodicals. Between 1850 and 1860 he published no less than twenty-five of these essays on a great variety of subjects elucidating the principles of evolution, and illustrating their biological, social, intellectual, moral, and political applications.

Among the subjects then dealt with, Mr. Spencer's thoughts were especially and powerfully attracted to the working of evolutionary law in the sphere of mind. This was a new point of view in mental science. While metaphysicians were confining their studies mainly to mind as an abstraction

* A noteworthy illustration of this has come to hand since the present article was put in type. The first part of Spencer's "Education"—"*What Knowledge is of Most Worth?*"—has just been translated into modern Greek by the late Minister of Education in Greece. It is significant that, while the New World colleges are neglecting and resisting modern knowledge, that the traditional ascendancy of ancient classics may be maintained, the Greek authorities, on the old, sacred, classical ground, are modernizing their education upon the principle that, in the hierarchy of knowledges, science is supreme.

and in its highest form, Mr. Spencer was drawn to its study in the aspect of growth, and as an endowment of growing organisms. Mind, as conditioned by a nervous substratum and unfolding with it—the genesis of the psychical faculties in all grades of organic manifestation—the law of mental progression from the lowest to the highest animate creatures—these were the problems that absorbed his attention. They were considered in various detached papers, but the subject was also dealt with elaborately and systematically in his treatise on the "Principles of Psychology," published in 1855. Mental phenomena were here first methodically elucidated from the evolution point of view. The development of intelligence was traced upward through the organic series from its lowest rudimental forms through successively higher complications, with the view of determining how the highest forms are produced and the highest intelligence constituted. Ascending from reflex action in the lowest types up through instinct, memory, reason, feelings, and the will, Mr. Spencer then reversed the course of inquiry, and showed by subjective analysis how the highest intelligence may be resolved, step by step, from its most complex into its simplest elements. The work was throughout so original and so closely reasoned as to make an epoch in the advance of mental science; and John Stuart Mill declared it to be "the finest example we possess of the psychological method in its full power."

Thus occupied in working out the laws of mental unfolding, it was impossible that Mr. Spencer's thoughts should not have been strongly attracted at this time to the subject of education. Descended from a race of schoolmasters, skillfully taught by his father and uncle on rational principles, and alive to the gross deficiencies of current teaching, he was predisposed to take an interest in all questions of mental cultivation. But the special direction of his studies now forced the subject upon him in a new and most important aspect. Education as a *leading out* of the faculties is essentially a problem of the growth of the faculties; and no new light could be thrown upon the processes and order of mental evolution without at once and powerfully affecting the practice of the art of education.

Spencer's "Education," produced at this period, was written from the point of view here indicated. It contains no formal statement of the evolution theory, but it conforms to the main doctrine throughout. The key-note and controlling idea of the book is, that Nature has a method of intellectual, moral, and physical development, which should afford the guiding principles of all teaching. The book is a plea for nature in education, and a protest against tutorial aggression, and meddlesome overdoing on the part of teachers and parents. The chapter on "Intellectual Education," which was written first and published in 1854, treats of school processes in relation to the law of development of the faculties as it takes place naturally. Education is regarded as rightly carried on only when it aids the process of self-development, and it is urged that the course of study in all cases followed should be from the simple to the complex, from the indefinite to the definite, from the concrete to the abstract, and from the empirical to the rational, in harmony with the course of evolution at large. In the chapter on "Moral Education" the subject is again regarded from the point of view of natural development. The general truth here insisted upon is, that the natural rewards and restraints of conduct are those which are most appropriate and effectual in modifying character. The principle contended for is that the moral education of every child should be regarded as an adaptation of its nature to the circumstances of life; and that, to become adapted to these circumstances, it must be allowed to come in contact with them; must be allowed to suffer the pains, and obtain the pleasures, which do, in the order of nature, follow certain kinds of action. "Physical Education" is again an argument from the biological side for the unhindered development of the bodily powers against the artificial restraints and repressions of school regulation; and it maintains that, during the earlier portion of life in which the main thing to be done is to grow and develop, our educational system is much too exacting. The last essay written, "What Knowledge is of Most Worth" (1859), is placed first in

the volume, and is a vindication of the study of nature and the rightful supremacy of science in education. A memorable passage illustrates the change that must take place in the study of history when social phenomena come to be dealt with by the method of development.

Now, while, as we have already said, there is no formula of evolution in the book, and even the word occurs in it but rarely, yet Spencer's "Education" so entirely conforms to the doctrine, that, if it were rewritten to-day, it would hardly require revision in this respect. Mr. Spencer was, in fact, master of the new method at that time. If the reader will refer to the prospectus of Spencer's "System of Philosophy," which is prefixed to the volume, he will see how completely its author's views were matured, both in respect to the conditions, laws, and causes of evolution—the fundamental principles of the subject—and also of that detailed reconstruction of biological, psychological, sociological, and ethical science which evolutionary doctrine necessitates. The whole logical plan was traced out in its steps of dependence, and even in its proportions, with such singular accuracy, that he has hardly deviated from it in the twenty years subsequently devoted to its execution. The work on education was written while these views were taking definite shape in Mr. Spencer's mind, and half of it was written after his philosophical scheme was perfected. It was, of course, in advance of its time, and belonged to a stage of thought not yet reached either by the public mind generally, nor even in the enlightened circles of science. There was, as yet, but little talk of evolution, and when referred to it was generally derided by everybody as a vagary. Yet to Mr. Spencer's mind at this time evolution was not only a great truth, overwhelmingly demonstrated by concurring evidence from many sources, but it had become a principle of reorganization in large spheres of knowledge, and a new guide in the practical affairs of life. How thoroughly he had made the field his own, and how far in advance he was of even advanced thinkers, are sufficiently shown by the fact that, when Mr. Spencer tacitly based his treatment of education upon evolution doctrines which he had already wrought into an explicit and complete system, Mr. Darwin had, as yet, published nothing upon the subject.

We have here, unquestionably, one of the main causes of the success of this book. It anticipated and conformed to ideas that have since become widely popular. It has been increasingly appreciated because it has been found to harmonize with the striking results of advancing thought within the last twenty years. It has afforded trustworthy help in a time of transition when help is most urgently needed. Though a book of principles, it proved to be the most practical of educational manuals, because its principles were applicable to all circumstances, and it has become an authority because its indications have been attested by common sense, and verified as true by experience.

It is well, then, that we are to have a cheap edition of this instructive book, and all the better that it is in good print and in an attractive form. It ought to be extensively circulated among teachers and educational officials in this country, because, with our favorite system of State instruction, we are strongly inclining to the evils against which this book so powerfully protests. The machine-education of great school establishments is a system of external coercion which everywhere tends to thwart spontaneous natural development, and to hinder instead of facilitating self-education. It is the small minority of thinking persons in each country that has called for and commended Mr. Spencer's work; the great multitude of teachers know little of it. And, while as victims of a great mechanical system they are left but small liberty in the application of principles, and none at all of principles that contravene the official mechanics of the schoolroom, it is, nevertheless, desirable that they should be made to understand, as clearly as possible, the drawbacks of the system under which they work.

The extensive circulation of this book, both among teachers and parents, would be highly promotive of rational education; and liberally disposed people would do an effective philanthropic work by purchasing it at wholesale and donating it to those who are not familiar with its views.

It may not be improper to add, in these

times of wholesale piracy of the valuable works of foreign authors, that Mr. Spencer will continue to be paid by the publishers on this cheap edition of his "Education" just as he has been paid by them from the beginning on all his other publications.

NEW DEPARTURES IN COLLEGIATE CONTROL AND CULTURE. By Rev. CALEB MILLS. New York: A. S. Barnes & Co. Pp. 50. Price, 30 cents.

THE Rev. Caleb Mills, a graduate of Dartmouth College and of Andover Theological Seminary, was for forty years Professor of Greek at Wabash College, Indiana. He became the first Superintendent of Schools in that State, and so impressed his views upon its people as to earn the flattering title of "Father" of the Indiana common-school system. He died last October, and left this essay on the higher education as a last message to scholars and the people, and his friend Henry B. Carrington has seen it through the press in a very careless way.

The paper is mainly an argument on college methods with reference to alleged modern improvements in the studies and the management of these institutions. Mr. Mills clings tenaciously to the traditions, and strenuously resists all the new-fangled notions about optional studies and the introduction of modern languages, scientific branches, and practical knowledge into the collegiate curriculum. Only classics and the dead languages, he maintains, can give a liberal education, or that mental discipline which is the real object to be gained in all higher study.

Mr. Mills appears to think that it is the duty of colleges to go on to the end of time threshing the old Latin and Greek straw, although it has long since ceased to yield the grain that is commonly supposed to be the object of threshing. He seems, in fact, to think it a great point gained that the old dead straw no longer furnishes anything that can be utilized. Grain and bread and nourishment are sordid and vulgar things, which the thresher should no longer think of, and so the more empty and useless the husks the better. The real thing is the muscular exercise in the use of the flail, the noble discipline of his arms; for, when he has vigorously pounded the Greek and Latin litter for some years, he will get wonderful vigor for other forms of exercise.

Mr. Mills has various animated passages in denunciation of college reforms, but we can not see that he contributes anything important to the argument. The coolness with which he throws aside all modern knowledge, as of little or no account in higher education, is something surprising, and shows the havoc that forty years of Greek may make with a man's common sense.

Mr. Mills is greatly concerned about the use of the Bible as a college text-book; and the question of its more general employment in this way he declares to be "a live issue," which involves little less than the destinies of the nation. One of the bad signs of collegiate degeneracy is a neglect to use the Bible as a text-book. He informs us that reliable statistics show that "of forty-six colleges reporting, eighteen use it in a proper sense as a text-book and twenty-eight do not. Of twelve New England colleges, three use it and nine do not. Of twenty-two Western institutions, nine use it and thirteen do not give it a place in their curriculum."

Among the reasons for making the Bible a text-book in our colleges, Mr. Mills thinks that it would raise us in the estimation of the pagans, whose example in this respect he thinks it scandalous that we have failed to follow. He says: "Were an American Christian to go into the Mohammedan university at Cairo, with its ten thousand students, nothing there witnessed would impress him so deeply as the fact that so much time is occupied and so much attention given to the study of the Koran; and a like impression would be created were he to make a similar visit to a corresponding institution in the sacred city of Benares, and witness the exercises of that Brahmanical college, and listen to the lectures of its learned pundits on the Shasta literature and religion; if, then, returning to his native shores, he should make a corresponding exploration of some of *our* colleges, proud of their number of students and the spread of their curricula, and ask the venerable presidents thereof, Why has not the *Bible* place, if not a prominent one, at least a position, in your course of study? what reply would he receive?"

THE MORALS OF EVOLUTION. By M. J. SAVAGE, author of "The Religion of Evolution." Boston: George H. Ellis. Pp. 191. Price, $1.

WE congratulate Mr. Savage, first of all, on his standpoint in the treatment of moral questions. He has at once taken the advanced and unassailable ground that ethics is properly a branch of science to be investigated like all other kinds of knowledge, and that it forms no anomaly or sacred exception in relation to that common method by which truth of all kinds is sought and established. He is hampered by no restraints of authority in inquiring into the grounds and sanctions of right conduct, but discusses problems in the full freedom of reason and under the profound conviction that only in this way can an authoritative and well-based moral system ever be attained by man. And Mr. Savage uses his freedom with the best effect. He throws much light upon the practical aspects of the subject from the new point of view, and shows the adequacy of the canons of natural morality for guidance in the conduct of life. He makes no claim to work out a rigorous ethical scheme, but contents himself with a popular exposition of the principles of right and wrong action as they are affected by the progress of knowledge and those new views of the nature of man which evolution has forced upon the attention of the world. His style is familiar, his illustrations apposite, and his reasoning clear and forcible. His book will be found helpful and instructive to many minds, and the same thing may be said of the course of liberal sermons which he has delivered from the Unity pulpit in Boston, and which are printed as a series of neat tracts. The contents of the present volume at first took this form of pulpit discourses; and it is encouraging that at least one large congregation has been found sufficiently intelligent and liberal not only to tolerate, but to accept and appreciate them.

BRAIN AND MIND; OR, MENTAL SCIENCE CONSIDERED IN ACCORDANCE WITH THE PRINCIPLES OF PHRENOLOGY, AND IN RELATION TO MODERN PHYSIOLOGY. By HENRY S. DRAYTON, A. M., and JAMES MCNEILL. New York: S. R. Wells & Co. 1880. Pp. 334. Price, $1.50.

THE authors here give a restatement of phrenology, with a great many cuts of heads, and a claim that the phrenological system has been affiliated upon the principles of the later physiology. It is generally considered that the results of the most modern researches into the nervous system contravene phrenological doctrine as formerly expounded. How far they are capable of reconciliation we will not undertake to say, but if anybody is interested, and will get this book, he will be in possession of perhaps the latest attempt at harmonization.

SEA-SICKNESS. By GEORGE M. BEARD, A. M., M. D. New York: E. B. Treat & Co. 1880. Pp. 74. Price, 50 cents.

IN this little work Dr. Beard has made a careful study of this distressing malady, and advances a theory of its nature, which, he claims, harmonizes with all the facts, and a mode of treatment which is effective. He holds that it is a "functional disease of the central nervous system, mainly of the brain, but in some cases of the spinal cord also." The symptoms, which he says have never been before clearly described, he gives as headache, backache, nausea without vomiting, vomiting, pain in the eyes, constipation and diarrhœa, menstrual suppression, hopelessness and mental depression, temporary abnormal appetite, neuralgic pains, chilliness with flashes of heat, sleeplessness, and nervous exhaustion. These symptoms are all due to the agitation of the nervous system by the motion of the ship. This view of the disease is quite at variance with the popular and even professional one, which has regarded it as an affection of the stomach and digestive apparatus. Among the considerations brought forward by Dr. Beard in support of his view is the fact that the very young and the very old are seldom or never troubled with it. "It is," he says, "the disease of active cerebral life, between fifteen and sixty-five," being in this respect like sick-headache, which we now know to be a nervous affection. In further support of this theory, observation shows the delicate, finely-organized, and nervous to be more liable to sea-sickness than the strong and phlegmatic. The treatment advocated by Dr. Beard is based upon this view of the nervous character of the disease. It consists in giving such remedies before and during the attack as will reduce the sensitiveness of the central nervous system. He

has given his treatment extensive trial, and avers that it has rarely failed. The remedy he has found best of any is the bromide of sodium in doses of thirty to sixty grains, three times a day for several days before starting, and during the voyage, until all danger is past. The remedy should at first be administered by a physician, and can afterward be intrusted to the patient. Dr. Beard especially warns against the use of purgatives, spirituous liquors, and morphine or opium. With the bromine-treatment he states that the patient may remain on deck or in his state-room indifferently, and may eat such things as he may desire. He is also much less liable to take cold at sea or just after landing.

THE THROAT AND ITS FUNCTIONS. By LOUIS ELSBERG, A. M., M. D. New York: G. P. Putnam's Sons. 1880. Pp. 60. Price, $1.

THIS is one of the popular scientific lectures given under the auspices of the New York Academy of Sciences, and the subject, as befits such a course, is treated in a manner to make it clear to the unscientific. Dr. Elsberg describes the various parts of the throat and their function in speaking, and some of the instruments used in examinations of the throat, and closes his lecture with a description of Edison's phonograph, which he exhibited to his audience.

ALVA VINE; OR, ART VERSUS DUTY. By HENRI GORDON. American News Company. Pp. 233.

THIS is a sketch, a fancy sketch, of what the author calls "a suggestive woman of the republic — a girl with a good *physique*, a cultivated mind, a large heart, capable of taking an interest in all that appertains to the welfare of the whole human family." It is a *very* fancy sketch.

A STUDY OF SOME OF THE STARCHES. By MRS. LOU REED STOWELL, M. S., Microscopical Laboratory, University of Michigan. Ann Arbor, Michigan: Courier Steam Printing-House. 1880. Pp. 17. Price, 15 cents.

THIS is a brief description of the appearance under the microscope of some of the more common starches, with instructions how to study them. The starches considered are those of potato, arrowroot, wheat, barley, bean, pea, corn, rice, oat, buckwheat, sago, tapioca, turmeric, and ginger.

THE MANAGEMENT OF CHILDREN, IN SICKNESS AND IN HEALTH: A BOOK FOR MOTHERS. By ANNIE E. HALE, M. D. Philadelphia: Presley Blakiston. Pp. 110. Price, 50 cents.

No better fifty cents' worth of a book for mothers have we seen in a long time. It is full of just the kind of information that all mothers require to possess, and this information is imparted in a simple and sensible manner, so that it may be perfectly understood. The points of most importance are given emphatic prominence, and the subjects are treated throughout with excellent judgment. It is one of the little manuals that can not be too strongly commended.

PROBLEMS IN RELATION TO THE PREVENTION OF DISEASE. By J. R. WEIST, A. M., M. D. Richmond, Indiana: Telegram Printing Co. 1880.

THIS is the address of the President of the Indiana State Medical Society at its session of this year. Dr. Weist points out the great losses, commercial and other, that result from an ignorance and disregard of sanitary conditions, and insists upon the necessity of legislation in the matter. He contends that the aim of physicians must be more and more to prevent rather than cure disease, and urges the consideration by them of such problems as have direct bearing upon public hygiene, a number of which he briefly indicates.

THE PROBLEMS OF INSANITY. A Paper read before the New York Medico-Legal Society, March 3, 1880. By GEORGE M. BEARD, A. M., M. D.

DR. BEARD declares, probably with much truth, that psychology is to be the great absorbing study of the future, and, in the study of the human mind, a thorough understanding of insanity will not only be of the greatest help, but indispensable. Among the problems he indicates as demanding attention are the proper definition of the disease, the general causes of it and of its increase in modern life, its real or apparent increase among the poorer classes, its diagnosis, and the proper system of treating it. In considering its increase Dr. Beard points out as

fruitful in results the increased friction of modern life, especially in the sphere of emotion, reaching the conclusion that the increase is "not so much among the most intellectual as among the least intellectual and highly emotional classes of civilization." The essay is throughout suggestive and well worth perusal by those interested in one of the most important fields of scientific investigation.

NEW CHARACTERS OF MOSASAUROID REPTILES. By Professor O. C. MARSH. Reprint from "The American Journal of Science." Illustrated.

THE remains of mosasauroid reptiles, though first discovered in Europe, were of such rare occurrence as to offer only limited opportunities for study; but they have been found in abundance in this country, and the Museum of Yale College alone has a collection containing some fourteen hundred distinct individuals, representing several families and numerous genera and species. This profusion has enabled Professor Marsh to make a very thorough examination of the group, and he has been rewarded by the discovery of several new characters, the more prominent among them being the presence of a sternum probably common to all the forms, the possession of posterior limbs, and of hyoid bones.

BULLETINS 1, 2, 3 (Vol. V.), of the UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES. Washington: Government Printing-Office. 1879.

THESE numbers make a volume of five hundred and twenty pages, comprising twenty-five articles, giving results of original work in the natural history, geography, physical features and resources of a portion of our Western Territories. Among others, Professors Riley, Cope, and White, Dr. Coues, Dr. Le Conte, and Mr. Henry Gannett, have each contributed to the volume.

A GUIDE TO MODERN ENGLISH HISTORY. By WILLIAM CORY. Part I., 1815–1830. New York: Henry Holt & Co. Pp. 269. Price, $2.

THIS book, the author says, has grown out of an attempt made a few years ago to give some account of English politics to a foreign guest, who was not a Christian or a European, but who at the time was reading English history for examination. Without attempting to adhere to the plan of adapting statements to so remote a mind, the author has thought it good to explain many terms which in ordinary books are assumed to be understood; and he has done it very successfully, in a plain, pleasant style, under the form of a running review of the principal events and political movements of the period embraced.

INTRODUCTION TO THE STUDY OF SIGN-LANGUAGES AMONG THE NORTH AMERICAN INDIANS, as illustrating the Gesture-Speech of Mankind. By GARRICK MALLERY, Brevet Lieutenant-Colonel United States Army. Issued by the Smithsonian Institution, Bureau of Ethnology, Washington, 1880.

THIS is the second of an important series of papers on American ethnology; the first, issued some time since, being an "Introduction to the Study of Indian Languages," by Professor J. W. Powell. A third is to follow on "Mortuary Observances and Beliefs concerning the Dead," by Dr. H. C. Yarrow, of the United States Army.

The study of anthropology is growing rapidly in importance and interest in this country. Vast collections of whatever may illustrate it are being made, and these thoroughly scientific papers will facilitate and direct the work. They are among the most valuable issued by the Smithsonian Institution.

CAMPS AND TRAMPS IN THE ADIRONDACKS, AND GRAYLING FISHING IN NORTHERN MICHIGAN: A RECORD OF SUMMER VACATIONS IN THE WILDERNESS. By A. JUDD NORTHRUP, Syracuse, New York: Davis, Bardeen & Co.; New York: Baker, Pratt & Co. 1880. Pp. 302. Price, $1.25.

THE author has undertaken in this little volume to describe his life in the woods, his adventures and talks, exactly as they occurred, without invention or exaggeration, and to give truthful pictures of actual summer life in the Adirondacks. By introducing the companions of his journeys, actual men of education and refinement, but who left the shop and the school behind them for a holiday, he has made his story an entertaining one.

ANNUAL REPORT OF THE WISCONSIN GEOLOGICAL SURVEY for 1879. By J. C. CHAMBERLIN, Chief Geologist. Madison, Wisconsin: State Printer, 1880.

WE learn from this brief report that the work of the survey is approaching completion. Two volumes of the reports are now in the printer's hands; and a third, which, however, will be Vol. I. of the series, will shortly follow, and will be devoted to the general geology of the State.

DEUTSCH-AMERIKANISCHE APOTHEKER-ZEITUNG. Edited by Dr. GEORGE W. RACHEL, and published by the Pharmaceutical Publishing Company, 5 Gold Street, New York. Pp. 16. Illustrated. Price, $2.50 a year.

"THE Deutsch-Amerikanische Apotheker Zeitung" (German-American Druggists' Gazette) is a semi-monthly journal which has been started in the interest and as the organ of the German apothecaries, chemists, and physicians, of the United States. It promises original articles and correspondence from writers of recognized standing in their respective fields, notices and reviews of all that is new in the branches of science to which it is devoted, for which the American and European press will be consulted, market reports of drugs and chemicals, and free discussions. The numbers before us are filled with articles and paragraphs of scientific merit, comprehensive in scope, varied in character, and abreast with the times.

SILVER IN ITS RELATION TO INDUSTRY AND TRADE: THE DANGER OF DEMONETIZING IT. THE UNITED STATES MONETARY COMMISSION OF 1876: REVIEW OF PROFESSOR FRANCIS BOWEN'S MINORITY REPORT. By WILLIAM BROWN. Montreal: Printed by the Lovell Printing and Publishing Company. 1880. Pp. 134. Price, 60 cents.

THE purpose of this work is to present the arguments in favor of retaining silver money—"the money of industry," as the author calls it—in such a manner that they shall be plain to ordinary minds, and that interest in the discussions on the subject shall be shared by the people at large.

THE "Naturhistorische Verein für Wisconsin," which has existed as an unincorporated society in the city of Milwaukee for twenty-two years, has been incorporated as the Natural History Society of Wisconsin, for the purpose of investigating the facts pertaining to the natural history and ethnology of the State. Its first year's report, in the German language, contains notices of the papers read at the several meetings of the Society, and an essay on "Life on the Prairie," by Dr. Emil Ulrici. Dr. Ulrici also sends us a paper (in German), of which he is the author, on "the settlements of the Normans in Iceland, Greenland, and North America, in the ninth, tenth, and eleventh centuries."

PUBLICATIONS RECEIVED.

Diagram of the Progress of the Anthracite Coal Trade of Pennsylvania. With Statistical Tables, etc. By the Messrs. Sheafer. Pottsville, Pa. 1879.

On Fluid Extracts as prepared for the Coming Pharmacopœia. Detroit. 1880. Pp. 7.

Photometric Researches. By William H. Pickering. Cambridge: John Wilson & Son. 1880. Pp. 14.

Therapeutic Action of Mercury, pp. 27, and Mechanical Therapeutics, Chemistry, and Toxicology of Mercury, pp. 19. By S. V. Clevenger, M. D. Chicago. 1880.

The Felsites and their Associated Rocks north of Boston. By J. S. Diller. Pp. 13.

High Schools. By B. G. Northrop. Syracuse: Davis, Bardeen & Co. 1880. Pp. 26. 25 cents.

The School Bulletin Year-Book for 1880. An Educational Directory of the State of New York. Compiled by C. W. Bardeen. Syracuse: Davis, Bardeen & Co. 1880. Pp. 36, with Map. $1.

Memoirs of the Science Department, University of Tokio, Japan. Vol. II. On Mining and Mines in Japan. By C. Netto, M. E. Tokio: Published by the University. 1879. Pp. 54. Illustrated.

On the Ethers of Uric Acid. Second Paper. Dimethyluric Acid. By H. B. Hill and C. F. Mabery. From "Proceedings of the American Academy." Pp. 11.

The "American Journal of Philology." Edited by Basil L. Gildersleeve. Vol. I., No. 2. Baltimore: The Editor, May, 1880. Pp. 126. Quarterly, $1 per number, or $3 a year.

Bromide of Ethyl as an Anæsthetic. By J. Marion Sims, M. D., LL. D. Read before the New York Academy of Medicine, March 19, 1880. Pp. 22.

A Defense of Free Thought, together with a Theory of the Origin of Morals and Religion, and some Speculations on Immortality. By an Agnostic. Galveston, Texas. 1880. Pp. 52.

Annual Report upon the Surveys of the Northern and Northwestern Lakes, and the Mississippi River, in charge of C. B. Comstock. Washington: Government Printing-Office. 1879. Pp. 180.

The Fifty-sixth Annual Report of the Officers of the Retreat for the Insane at Hartford, Conn. Hartford. 1880. Pp. 36.

Hearing by the Aid of Tissue Conduction. The Mouth-Trumpet and the Audiphone. By Samuel Sexton, M. D. New York. 1880. Pp. 8.

Researches on Hearing through the Medium

of the Teeth and Cranial Bones. Reprinted from the "Philadelphia Medical Times." Pp. 4. And The Perimetric Dimension System. A General System of Measurement for Urethral, Uterine, Rectal, and other Instruments, and an Adaptable Metric Gauge. By Charles H. Thomas, M. D. Philadelphia. Pp. 4.

Percy's Pocket Dictionary of Coney Island. With Map and Illustrations. New York: F. Leypoldt. 1880. Pp. 120. 10 cents.

Graded Selections for Memorizing. By John B. Peaslee, A. M., Ph. D. Cincinnati and New York: Van Antwerp, Bragg & Co. Pp. 192. 50 cents.

The Liberal Hymn-Book. Edited by Eliza Boardman Burnz. New York: Burnz & Co. 1880. 25 cents.

University of Tokio. The Calendar of the Departments of Law, Science, and Literature. 1879–'80. Tokio: Z. P. Maruya & Co. Pp. 163.

Some Thoughts concerning Education. By John Locke. With Introduction and Notes. By the Rev. R. H. Quick, M. D. London: Cambridge Warehouse. 1880. Pp. 140. 90 cents.

Annual Report of the Chief Engineer of the Water Department of the City of Philadelphia for the Year 1879. Philadelphia. 1880. Pp. 100.

The Principles of Nature, etc. Also an Exposition of the Spiritual Universe. Given inspirationally. By Mrs. Maria M. King. Vols. II. and III. Hammonton, N. J.: A. J. King. 1880. Pp. 261 and 268. $1.75 per vol.

POPULAR MISCELLANY.

The Catskill Mountains.—Professor A. Guyot gives, in the "American Journal of Science" for June, the results and a map of the first scientific survey of the Catskill Mountains, which he has undertaken, and with the aid of interested assistants has so far successfully carried out. These mountains, though situated in the most populous and civilized part of the United States, and visited every year by thousands, are among the least known in our country. Yet several features of the group are well calculated to excite the curiosity of the scientific investigator, and to call for a thorough study of its plastic forms. Though a part of the Appalachian system, the range appears in it as an anomaly; for, while the other Appalachian ranges trend from the southwest to the northeast, the Catskills run at right angles to them, or from the southeast to the northwest. The Catskills also surpass all the neighboring ranges of mountains by two thousand feet of height. Professor Guyot has devoted the summer vacations of seventeen years to their examination. His map represents a surface of about four thousand square miles, of which the mountainous part proper occupies somewhat more than one half, or about twenty-four hundred square miles. The distances and bearings are computed from the points of the triangulation of the Coast Survey along the Hudson River as a base. The mountain region is divided by the Esopus Creek into two groups, differing considerably in their physical structure, the northern, or Catskills proper, and the southern Catskills or Shandaken Mountains. "The northern group, or Catskills proper, between the Esopus and Catskill Creeks, form a massive plateau having the shape of an irregular parallelogram, extending from southeast to northwest, and shut up between two high border chains, ten or fifteen miles distant from each other, running about in the same direction. The southwest border is formed by what may be called the central chain of all the Catskills, the other by the northeast border chain. The southeast end is closed by the short chain of the High Peak; the northwestern by the high swell of plateaus which divide the headwaters of the Delaware and Susquehanna from those of the Schoharie Creek and the Hudson. Inside of this highland, three secondary ranges, starting from the northeast border chain and running nearly west, almost to the foot of the central chain, fill the inner space, inclosing deep valleys in which flow the waters of the Schoharie Creek and its tributaries. . . . A striking peculiarity of the plastic forms of the northern Catskill group is, that while its western end is, as it were, buried in the general plateaus of western New York, its mountains rising but moderately above their surrounding base, its eastern end stands isolated on three sides by deep and broadly open valleys, projecting, in all its height, as a mighty promontory, to within ten miles of tide-water in the Hudson River." The very base of its mountains rarely exceeds six hundred feet above tide. "No wonder, then," says Professor Guyot, "that the aspect of the Catskills is nowhere more imposing than from the Hudson River and the surrounding lowlands, from which their whole height is seized at a glance, and that it has been thus far believed that the highest points were found among the mountains of the eastern end." The panorama of the mountains, as seen from Catskill village, is

not a view of a single chain, but takes the eastern end of the border chains and the short range bearing the High Peak, which rises between the two. The Catskills do not present prominent examples of anticlinal and synclinal folds or arches, or fragments of arches, as in ordinary mountain-chains, but are masses of piled-up strata, seldom deviating notably from their original horizontal position. On account of this disposition of the strata, and their tendency to break at right angles to the planes of stratification, they are marked by the frequent abrupt ledges which are peculiar to them. For the same reason, the tops of the mountains are not pointed peaks, but are mostly flat surfaces, often of considerable extent. The central chain is the longest and most massive of the series, and is the backbone of the whole Catskill region. From Overlook Mountain to the Utsyantha, near Stamford, it is a little more than thirty-five miles long, and is divided into four almost equal parts by three deep gorges or cloves. The heights increase regularly from the Overlook to Hunter Mountain, one quarter of the way back, which, 4,038 feet high, is the highest point of the northern Catskills, overtopping High Peak, which has borne that name, by nearly four hundred feet. From this point the heights diminish to the Utsyantha, at the western end of the chain, whose height, 3,205 feet, is not greatly different from that of Overlook, 3,150 feet. The High Peak range, which is sandwiched between this range and the northern range, is only six miles long, and is distinguished by its High Peak, 3,664 feet high. The northeast border chain begins at South Mountain, near the Catskill Mountain House, which is 2,497 feet high, culminates at Black Dome, 4,003 feet high, and ends at Leonard Hill, 2,649 feet high, showing a similar rapid rise for a quarter of the distance, and a gradual fall toward the western end with the central range. The highland between these two chains, an irregular parallelogram twenty-seven miles long and from six to fifteen miles wide, is filled by three ranges, which are separated by valleys in which flow the tributaries of Schoharie Creek. This stream and its tributaries furnish the entire drainage for the interior highlands of the Catskills proper. The streams that run directly to the Hudson draw no water from the interior, but belong properly to the outside slopes. "This drainage, which sends the waters of the Catskills all the way around to the Mohawk to come back by the Hudson, after a course of one hundred and seventy-five miles, to within ten miles of their starting-point, is certainly remarkable, and betokens a very peculiar physical structure. This is made more striking by the fact that on both sides of these highlands the waters of the valleys of the Catskill and Esopus Creeks flow, as we might have expected, from the western plateaus directly to the Hudson River. The nearly horizontal position of the strata, which is common to the mountains and the surrounding plateau, and the peculiar features of the drainage, lead to the inference that the plastic forms of the Catskill region are the work of erosive forces, and are not due to the ordinary dynamic process which has folded and shaped the other parts of the Appalachian system. "We may, therefore, conceive the original form of the Catskills to have been that of a high plateau, a mass of elevations forming a part of the Appalachian plateau region which extends west of the Alleghanies from south Virginia, and fills nearly all the western portion of the State of New York south of Lake Ontario and the Mohawk River. The lowest altitude of the primitive plateau is marked by the ideal plane which would pass through the mountain-tops, and its superior elevation on the east would account for the flow of the waters, the gradual scooping out and the sloping of the valleys in the direction they now have." The southern Catskills have not the regular features which characterize the northern group; the boundaries are not well defined, except along the Esopus Valley; and, instead of their having an interior plateau inclosed by high border chains, the massive central chain, which bears the highest summit, is accessible from all the surrounding valleys without crossing any high pass. Their general direction is about the same as that of the northern Catskills, but several important ridges run at right angles to this direction, and impart considerable physical irregularity to their structure. The Slide Mountain, the culminating point of this group, is the highest of

all the Catskills, measuring 4,205 feet, and is the hydrographic center of the region, whence the waters run to the northwest by the Esopus, to the northeast by Woodland Creek, to the south by the Rondout to the Hudson, and to the southwest by the Nevisink to the Delaware. The geological structure of the group is similar to that of the northern Catskills. Professor James Hall has announced that, after four years of observation, he has detected the existence of four lines of anticlinals, nearly parallel to each other, and running from southwest to northeast, in conformity with the ordinary trend of the Appalachian range. Professor Guyot is willing to acknowledge the fact, but calls attention to the other fact that these axes cross the chains and valleys almost at right angles, "and were probably posterior to the scooping out of the valleys and mountain-chains, on the conformation of which they had so little effect. . . . A hypsometric feature, which may refer to this order of facts, is that the three maxima of altitudes above four thousand feet, the Slide Mountain, Hunter Mountain, and Black Dome, are situated in a straight line, trending from southwest to northeast."

Silicified Forests of the Yellowstone Park.—In Bulletin No. 1 of Vol. V. of the "Geological and Geographical Survey of the Territories," Mr. W. H. Holmes gives an account of a most wonderful geological formation, which attains its greatest development in the valley of the east fork of the Yellowstone River. It occurs in horizontal layers, having an aggregate thickness of fifty-five hundred feet, that is, the whole formation at this point is a little more than a mile in depth. This is filled throughout with the silicified remains of a multitude of forests, many of the trunks of trees that are still to be seen being of very large size. Some of them are prostrate, and from fifty to sixty feet long; others are upright where they grew, and some of the stumps measure from five to six feet in diameter. One gigantic trunk is described that stands twelve feet above the eroded strata about it, and is ten feet in diameter. This trunk is hollow, but the woody structure of what remains is well preserved, the rings of growth being clearly defined. The bark on this stump is four inches thick, and on its outer surface deeply lined. Scattered through the formations among the trunks is a great variety of vegetable remains, consisting of branches, rootlets, fruit, and leaves. Specimens submitted to Professor Leo Lesquereaux have been identified as follows: Aralia Whitneyi, Magnolia lanceolata, Laurus Canariensis, also new species of Fraxinus, Cornus Alnus, Tilia, Diospyros, Pteris, and Fern. The wood is in many cases completely agatized, and cavities which existed in the decayed trunks are filled with crystals of calcite and quartz. The formations are of the "Volcanic Tertiary," and composed of fragmentary volcanic products, breccias, conglomerates, and sandstones, the two former consisting chiefly of basalt. Many are of great size, and are cemented together in enormous masses or heavy beds by tufaceous and other fine-grained material. These beds or layers represent successive formations, arising from the subsidence of the land, during the intermissions of which the forests grew. The beds have evidently been changed by the action of water; and the conclusion is that the formation represents the shore or margin of a great Tertiary lake. It is believed that the beds cover or have covered an area of over ten thousand square miles.

Germs of Disease in Water.—Professor Huxley, in a recent discussion of a paper by Dr. Tidy on water for dietetic purposes, said that diseases caused by what people not wisely call germs are produced invariably by bodies of the nature of bacteria. These bodies could be cultivated through twenty or thirty generations, and then, when given under the requisite conditions, would invariably cause their characteristic disease. Bacteria are plants, and we know under what conditions they can live and what they will do. They can be sown and will thrive in Pasteur's solution, just as cress or mustard in the soil; and, if a drop of this solution were placed in a gallon of water, Professor Roscoe thinks it doubtful if there is any known method by which its constituents could be estimated. Every cubic inch of such water would contain fifty thousand to one hundred thousand bacteria, and one drop of it would be capable of exciting a putrefactive fermentation in any substance

capable of undergoing that fermentation. The human body may be considered as such a substance, and we may conceive of a water containing such organisms which may be as pure as can be as regards chemical analysis, and yet be, as regards the human body, as deadly as prussic acid. This is a terrible conclusion, but it is true; and, if the public are guided by percentages alone, they may often be led astray. The real value of a determination of the quantity of organic impurity in a water is that by it a shrewd notion can be obtained as to what has had access to that water. If it be proved that sewage has been mixed with it, there is a very great chance that the excreta of some diseased person may be there also. On the other hand, water may be chemically gross, and yet do harm to no one, the great danger being in the disease-germs.

Man in America.—Professor Flower, in a recent lecture on the "Anatomy of Man," before the Royal College of Surgeons, London, discussed at some length the question of his origin on the American Continent. Till recently, opinions on the early peopling of America had been divided between the views that the inhabitants of this continent were a distinct indigenous people, and therefore not related to those of any other land; and that they were descended from an Asiatic people who, in comparatively recent times, passed into America by the way of Behring Strait, and thence spread gradually over the whole Continent. These theories have had to undergo considerable modifications in consequence of the discovery of the great antiquity of the human race in America, as well as in the Old World. The proof of this antiquity rests upon the high and independent state of civilization which had been attained by the Mexicans and Peruvians at the time of the Spanish conquest, and the evidence that that civilization had been preceded by several other stages of culture, following in succession through a great stretch of time. The antiquity of this quasi-historical period is, however, entirely thrown into the shade by the evidence now accumulating from various parts of North and South America, that man existed on the Western Continent, and under much the same conditions of life, using precisely similar weapons and tools, as in Europe during the Pleistocene or Quaternary period, and perhaps even farther back in time. Recent paleontological investigations show that an immense number of forms of terrestrial animals, that were formerly supposed to be peculiar to the Old World, are abundant in the New. Taking all circumstances into consideration, it is quite as likely that Asiatic man may have been derived from America as the reverse, or both may have had their source in a common center, in some region of the earth now covered with sea.

Illusions and Apparitions.—All illusive visions and apparitions are susceptible of a scientific explanation. They originate in some derangement of the brain and nervous system, and are for that reason most likely to occur to persons who are out of health. The apparent reality of some of these illusions is often wonderful, and might well prompt those who are not acquainted with nervous physiology, or who have not devoted careful attention to the subject, to refer them to something out of the common. Even while we are in perfect possession of our faculties, we imagine that we see objects before us as clearly as though they were actually present, or hear, with equal distinctness, sounds which have no real existence outside of ourselves. The explanation may be found in a simple study of the physiology of the nervous system, and shows that the illusions have a material basis. Our sensations are transmitted from the organ that receives them to the brain, and it is the brain, not the organ, that experiences them and is their seat. In the case of sight, it is the function of the eye to receive and adjust the rays of light coming from the object that we see, so that they shall produce an impression on the brain. The eye represents the lenses of the photographer's camera; but the brain corresponds to the sensitive plate which receives the image, and on which all subsequent alterations of the image are effected. Similar relative parts are played by the organs and the brain in the case of the other senses. Now, if a similar impression to that which is transmitted to the brain from the organ of sense is produced upon it by any other cause, the same kind of a sensation will result. This may happen when the brain

is in an excitable or irritable state from ill health or any other cause, and is enough to explain all the phenomena under consideration. The visions most often correspond to our previous experiences, and therefore represent objects we know. Sometimes, however, the images are unfamiliar, and they are then referred to objects that we have seen, but have ceased to remember in our natural condition. The apparitions are thus explained as the creatures of our imagination, which, through some brain-disturbance, is enabled to project its visions forward on the seats of sense, just as the ringing in the ears, with which we are all familiar, is produced by some irritation of the hearing-center of the brain.

Soils as Filters.—Dr. Victor C. Vaughan, of the University of Michigan, has described in "The Sanitarian" some experiments which he has made to determine the power of soils to prevent the filtration of organic matter in solution. They had reference to the questions, To what extent are organic substances removed from solution by filtration through the soil; and do different soils differ in their capability of thus removing organic matter? Urea was selected as the substance with which the experiments should be tried, and urine as the fluid with which filtration should be performed. The ordinary gravel soil of Michigan was found to produce but little effect in detaining the urea, while it soon became saturated; and the conclusion was drawn that the secretions from a family of six persons each day would be sufficient, when properly dissolved, to saturate more than seven cubic feet of this soil, and that only a few weeks or months would suffice, with a proper amount of rainfall, to saturate every cubic foot of soil to the depth of five or ten feet in a small yard. Gravel, however, is the poorest of filters, for the spaces between the particles allow the liquid to run through freely at certain points. Sand and loam exhibited a more satisfactory action, the loam more so than the sand, both these substances receiving a perceptibly larger quantity of urea before they were saturated. This is probably owing partly to their greater uniformity of constitution, in consequence of which water can not run as fast through them as through gravel, and partly to their greater porosity, by means of which matter passing through them is more closely exposed to the action of oxygen, the most efficient agent for the destruction of organic impurities.

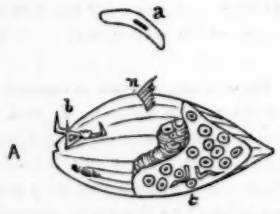
Freezing of a Lake by Radiation.—A remarkable instance of the freezing of water in consequence of the radiation of heat was remarked in the Lake of Morat, Switzerland, after the cold weather of March last. The lake, of which three fifths of the surface had been covered with ice, was clear on the 8th of March, and the weather had become warm. During the night of the 10th of March, the thermometer did not descend to the freezing-point; yet on the morning of the 11th the lake was covered over with a thin sheet of ice. The Lakes of Neufchâtel and Constance were similarly covered. The freezing is accounted for by supposing it to have been occasioned by the rapid and great radiation of heat which took place on a perfectly clear night. An intense degree of cold had been necessary to cause the lakes to freeze during the cloudy weather of the previous cold spell, and the freezing was then very irregular and unequal.

Effects of Diseased Meat.—Mr. Julius Hardwicke, F. R. C. S., an English local medical officer of health, recently read a paper at a sanitary meeting on "Meat as Food for Man," in which he considered the effects of diseased meat on the human system. The evidence on this subject is of the most conflicting character. According to Dr. Letheby, enormous numbers of animals that died of rinderpest in 1863, and more recently of pleuro-pneumonia, have been sent to the London market and eaten without having produced any tangible effects; the Scotch eat "braxy" mutton with impunity, and, some say, even prefer it to sound mutton; and the people of Paris must have eaten much diseased meat during the siege, though we have no account of their having suffered from the effects of it. The symptoms or complaints of those supposed to be suffering from having eaten diseased meat are very similar to those occasioned by the use of putrid meat. Para-

sitic disease is quite different. Dr. Parkes names as the diseases of cattle that should be watched for: Pleuro-pneumonia, foot-and-mouth disease; cattle-plague, or rinderpest; anthrax, or malignant pustule; simple inflammatory affections of the lungs; dropsical affections from kidney or heart disease; indigestion with apoplectic symptoms. The first three are described as contagious, and the last three as sporadic diseases, in a work by Professor Williams, of Edinburgh. To this list Mr. Hardwicke adds, as contagious, glanders and farcy (which may be communicated to consumers of horse-meat), puerperal apoplexy, and variola. He also adds a list of epizoötic diseases, meaning diseases occasioned by parasites, including measles in the pig; rot, or fluke disease, in sheep; gid, turn-sick, or staggers, in sheep; phthisis, or hoore, in cows, pigs, and poultry (gapes). The diseases of sheep are similar to those of cattle. They are subject to small-pox, malignant pustule, a parasitic chronic lung affection, and braxy or splenic apoplexy. Pigs are subject to anthrax, typhoid, and hog-cholera. The contagious diseases are communicable by contact, by inoculation, and by infection. Hence it is not safe to let any of these classes of diseased meat go forth to the public as fit for consumption. To the opinion that cooking will destroy the contagious property and render the food fit for use, Mr. Hardwicke replies that there is no proof of it. Meat subjected to a temperature of 160°, which it is thought will thoroughly cook it, may still be productive of disease by inoculation. We are yet ignorant of the nature of the contagious property, and, if it be a living germ, what proof have we that, even if we succeed in destroying this germ and the entozoön of parasitic disease, a possible potent matter produced by the germ or ova of entozoön may not still exist and possess infective qualities?

The Milky Sea.—The peculiar coloration which has given the name of the milky sea to certain regions of the ocean has been remarked by many sailors, but a diversity of opinion has been expressed as to the cause of the phenomenon. Some have attributed it to electric action taking place during the hours preceding a storm; others to chemical combinations resulting from the decomposition of the bodies of marine animals and plants, and producing phosphorescence; others to spawn deposited on the surface of the water, which is supposed to be made to shine by the moving of masses of fish through it. None of these hypotheses have been confirmed, but they have all been contradicted by positive evidence that the milky sea is produced by a prodigious accumulation of animalcules, capable of becoming phosphorescent spontaneously, or of being made so by friction. The most recent and decisive evidence in this direction was observed on board the French ironclad Armida, on her recent voyage from Japan, while crossing from Point-de-Galle to Aden. At about half-past twelve in the morning of the 10th of February, 1880, the sky being clear, with no moon, the western part of the horizon, toward which the ship was going, became so bright as to attract the attention of the officer of the quarter. He at first thought the light was occasioned by the numerous bright stars which were about setting, but the increase of the light caused him to change his opinion, and he concluded that it was from a ship on fire. A half hour afterward a layer of whitish foam appeared covering the water for a considerable extent. The whole sea, shining with a milky luster as brightly as the usual phosphorescence which a ship produces in its passage through the water, resembled a field of snow in a clear night. It shone enough to efface all traces of the undulations of the swell; the waves could not be distinguished; and the sea seemed as flat and even as in a calm. The wake of the ship (which is generally visible for two or three miles back), and the disturbance of the water by the screw were hardly marked on the still surface. These facts proved that the luminous coating was not merely superficial, but that it had a considerable thickness. The phenomenon became more marked and intense, and one observing it might have believed he was locked in a sea of ice, had there been no movement of the ship to undeceive him. By daylight all had disappeared. On looking closely at the water as it rippled along the ship, there were noticed a great

quantity of luminous particles pressed closely one upon another, the most brilliant ones being those which had been in contact with the bottom. The water when taken up in a bucket appeared to be full of phosphorescent bodies, from a half to three quarters of an inch long, which sparkled when they were brushed about by the hand. Nearly four hundred of them were counted in a bucket holding ten quarts. When taken from the water and examined by the light of a lamp, they were seen to be formed of a gelatinous substance which dried up quickly in the air and disappeared, leaving a dark globule a millimetre in diameter (see figure), which could be made lively again, and capable of becoming luminous, by putting a drop of water upon it. When rubbed in the hand, the bodies left a bright train which soon went out, leaving no odor. The globules under the compound microscope were transparent, filled with eggs of an ovoid shape, and were continually agitating their fins and tentacles. The organism is ellipsoidal and full of eggs, which are contained in an internal sac; the internal tentacles, *t*, always in motion, keep the eggs in circulation. The exterior tentacles, *b*, have a motion like that which we make in stretching out the arms, drawing them back and bending the elbows. The object marked *n* is a comb-shaped fin, with twelve or fifteen bones. The epidermis is striated in the direction of the major axis of the ellipse. When kept till daylight and examined in a dark room, the water gave no light; it was of no use to shake or stir it, the bodies had lost their phosphorescent property. Fresh water, drawn up in the daytime and stirred in the dark, likewise showed no phosphorescence, although the color of the waters, a dirty-blue bordering upon gray, indicated that the ship was still close to the milky sea. On the next evening the milky tint came on again, all at once, at about seven o'clock, an hour and twenty minutes after sunset and an hour after dark. The beautiful appearances of the preceding night were again observed, but the whitish reflection in the horizon more resembled a fog which obscured it and made it seem nearer. Drops of water examined by themselves in the microscope revealed filaments of marine plants and numerous proliferous vegetable cells. The animalcules were the same as before, and were the only luminous objects. The nights of the 9th, 10th, 12th, and 13th of February were thus adorned with the splendor of the milky sea; during this time the ship had passed through six hundred and sixty miles, or two hundred and twenty marine leagues, in a mean latitude of 12° north, between the sixty-first and fifty-first meridians of east longitude. The atmosphere was in its normal condition, as was also the sea; the moon was new, the sky was clear, the barometer and thermometer were steady. No storm was near; no change was observed in the hydrometric condition of the air; the monsoon had been blowing a light breeze from the northeast for a considerable period. Several officers on board had previously witnessed this interesting spectacle in different places, as the Gulf of Aden, the Bay of Bengal, the Sea of Java, in hot latitudes, and during the months of January and February, but none of them had observed it when it was so bright, or had noticed it for so long a time.—*La Nature.*



A Phosphorescent Animalcule of the Milky Sea (natural size). A the dark globule seen in the center of *a* magnified.

The Health-Cure as a Remedy for Adversity.—The "Lancet" suggests that more account ought to be taken than is taken of the condition of health in estimating the causes of success or failure in life. The habit of failing is formed in some families, and seems to be transmitted by inheritance; the same is the case with constitutional peculiarities, and often with certain morbid conditions. It would be an interesting and profitable study to examine how far what is called ill luck or bad fortune is induced by such peculiarities. Accepting this view, "so far from its being strange that failure or success should 'run in families,' it

would be inexplicable, and contrary to every natural law and precedent, if it did not do so. The force of character, strength of will, clearness of mental vision, and qualities of vigor, patience, and perseverance, which constitute the secrets of success in life, are the several properties of the physical organism, compounded as it is of body and mind." A new cure is suggested, then, the "health-cure," as a remedy for adversity, which would be first personal, then hereditary in its aim, aspects, and bearing. The subject is worthy the attention of medical men and social philosophers.

Carrying a French Meridian into Africa.—Colonel Perrier furnishes a description to "La Nature" of the manner in which the French system of triangulations and the meridian lines have been extended into Algeria under his direction. The idea of establishing a geodesic connection across the Mediterranean had been entertained for more than seventy years, but it was considered doubtful, on account of the great distance from each other of the points that would have to be used in the observations, whether a correct measurement was practicable. Preparations for making the observations were begun in 1873. Four points were chosen (Mulhacen and Tetica in Spain, 11,537 feet and 676 feet above the sea, Filhaoussen and McSahiba in Algeria, 3,760 feet and 1,876 feet above the sea), which formed a quadrilateral the angles of which were all visible from each other. It was necessary, from considerations of climate and locality, to make all the observations in the latter part of the summer and the early fall. Solar reflections were to be used in the day, and the electric light at night, as signals. The solar reflections were never seen at any of the distant points, and proved a complete failure. After about twenty days of effort, the electric light was made visible at all the points, and was used successfully from the 10th of September till the 1st of October, when the first series of observations was satisfactorily completed. The calculations showed that, notwithstanding the extraordinary distances apart of the points of observation (one hundred and seventy miles), the solutions were as exact as in cases involving only a few miles. In making the astronomical projections of the points, a system of rhythmic signals, or of stated alternate flashes and eclipses of the electric light, was employed from the 5th of October to the 16th of November. It was found that these signals were susceptible of great precision, but that the personal equation could not be disregarded in observing them. This equation operated in a double sense, as related to the observation of the stars and of the signals, in each observer, and had to be ascertained by a series of special experiments instituted in the case of each person at the observatories at Paris. Practically, it was a matter of indifference to the observers whether they directed their attention to the flashes or to the eclipses of the light, but they considered the observations of the eclipses likely to be more exact. The most convenient rhythm of signals was found to be one of about two seconds, allowing one second for the flash and one second for the eclipse. The constancy of the personal equation as it related to the luminous signals was remarked, and the error to be allowed for was estimated at less than one hundredth of a second.

Mr. Fleuss's New Diving-Process.—We noticed in the March number of the "Monthly" the invention by Mr. Fleuss of a process for breathing under water, which dispenses for the most part with the cumbrous apparatus that divers have hitherto had to employ. A fuller account of the new method has been published since, in the English papers, and those features of it which were then kept secret have been disclosed. The power of breathing depends on means which are provided within the helmet worn by the diver. These means are designed to furnish a continuous supply of oxygen, and to dispose of the carbonic acid which the breather exhales. No provision is made for the nitrogen which enters into the composition of ordinary air, for this merely serves as a diluent, and is not changed or diminished in quantity by breathing; hence the nitrogen which is naturally present in the diver's lungs and in his dress when he puts it on can be used over and over again, and is amply sufficient for its purpose. The oxygen is stored in the helmet in a compressed state, and the supply is regulated by a valve which is un-

der the control of the diver. A solution of caustic soda, distributed through the pores of a mass of spongy India-rubber and confined in a close case, is provided for the disposition of the carbonic acid. A proper arrangement of tubing causes the whole of the exhaled air to pass through this case and its soda. A single charging with soda answers for a week of daily use of the apparatus. Mr. Fleuss exhibited his confidence in his apparatus by putting it on and going under water for the first time in his life, and remaining there for more than an hour.

NOTES.

PROFESSOR WILLIAM K. KEDZIE, formerly Professor of Chemistry and Physics in the Kansas State Agricultural College, and Professor of Chemistry in Oberlin College, died at Lansing, Michigan, April 14th, in the twenty-ninth year of his age. As Chemist of the Kansas State Board of Agriculture, he performed valuable analyses of the soils, minerals, and vegetable products of Kansas. He planned the laboratory of the Kansas Agricultural College, and was the principal originator of the Natural History Society of the Michigan Agricultural College. His chief published writings are a work on the geology of Kansas and a number of articles contributed to the Kansas Academy of Science.

SOUNDINGS of the Niagara River below the falls have been taken by a party of United States engineers. A line, cast out as near to the falls as they could be approached in a small boat and near to the shore, gave 83 feet. Farther down the stream the line told off 100 feet, and at the inclined railway 192 feet. The average depth of the swift drift, where the river suddenly becomes narrow with a velocity too great to be measured, was 153 feet. Immediately below the bridge, where the whirlpool rapids set in, the depth was computed to be 210 feet.

THE death is announced of Dr. J. G. Mulder, Professor of Chemistry in the University of Utrecht, in his seventy-eighth year.

PROFESSOR NICHOLAS ZININ, the eminent Russian chemist, died early in the present year, in the sixty-eighth year of his age. He was fifteen years a professor in the University of Kazan, after which, from 1848 to 1874, he was Professor of Chemistry in the Imperial Academy of Medicine at St. Petersburg.

THE Summer School of Zoölogy of the Johns Hopkins University is established on an island near the mouth of Chesapeake Bay, for a term of six weeks. The place abounds in living organisms in such variety that the student has an opportunity of studying representatives of nearly all the larger groups of animals, and is free from mosquitoes and extreme heat.

A SECOND specimen of the archæopteryx is on deposit in the Geological Museum at Berlin, with the expectation that it will be purchased. It was bought from its former owner for five thousand dollars by Herr Siemens, of Berlin, to prevent its being brought to this country.

M. CHEVREUL, who is now in his ninety-fifth year, has begun his course in chemistry at the Paris Museum of Natural History, with as much apparent zest and energy as he exhibited fifty years ago, when he first entered upon the duties of his chair.

GELOSE is the name of the most valuable constituent of the substance known in commerce as China moss. It has the property of absorbing and solidifying into a colorless and diaphanous jelly five hundred times its weight of water, and is capable of forming ten times as much jelly by weight as the best animal gelatine.

PROFESSOR DAVID THOMAS ANSTED, author of several works on geology and its applications, died May 20th. He was born in London in 1814, was appointed Professor of Geology in King's College, Cambridge, in 1840, and afterward Lecturer on Geology at other institutions, Assistant Secretary to the Geological Society, and editor of its quarterly journal.

PERTINENT to the discussion concerning the fertility of hybrids, it is stated that the fertility of the progeny of the hare and the rabbit has been established for several generations. The hybrids are known in France as léporides, and have been constituted by Haeckel into the species *Lepus Huxleyii*.

THE death of Professor Wilhelm Schimper, the distinguished Alsatian botanist, is announced. He was best known through his works on the mosses, in which department he was one of the leading authorities. He was also author of an important treatise on vegetable paleontology, and of several works on Alsatian botany and geology.

THE death of Dr. Rudolph H. C. C. Scheffer, director of the botanical gardens at Buitenzorg, Java, which took place March 9th, causes a loss which will be felt by a large circle of botanists throughout the world. He had been director of the gardens for twelve years, and was in communication with every home and colonial institution.

JOSEPH LEIDY.

UNIV. OF MICH.